CEREN ŞAHMARAN

EXPLORING AUDIO-VISUAL PERCEPTIONS OF STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) IN INFORMAL LEARNING ENVIRONMENTS

Bilkent University 2025

# EXPLORING AUDIO-VISUAL PERCEPTIONS OF STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) IN INFORMAL LEARNING ENVIRONMENTS

A Master's Thesis

by
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Department of
Interior Architecture and Environmental Design
İhsan Doğramacı Bilkent University
Ankara

September 2025

*To my lovely grandmother,*

*Aysel Öztaşan*

# EXPLORING AUDIO-VISUAL PERCEPTIONS OF STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) IN INFORMAL LEARNING ENVIRONMENTS

The Graduate School of Economics and Social Sciences
of
İhsan Doğramacı Bilkent University

by

CEREN ŞAHMARAN

In Partial Fulfillment of the Requirements for the Degree of
MASTER OF FINE ARTS IN INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN

THE DEPARTMENT OF
INTERIOR ARCHITECTURE AND ENVIRONMENTAL DESIGN İHSAN DOĞRAMACI BİLKENT UNIVERSITY
ANKARA

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By Ceren Şahmaran

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

—--------------------
Semiha Yılmazer
Advisor

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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Nuri Cihan Kayaçetin
Examining Committee Member

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Interior Architecture and Environmental Design.

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Arzu Gönenç Sorguç
Examining Committee Member

Approval of the Graduate School of Economics and Social Sciences

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Refet S. Gürkaynak
Director

# ABSTRACT

EXPLORING AUDIO-VISUAL PERCEPTIONS OF STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) IN INFORMAL LEARNING ENVIRONMENTS

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MFA., Department of Interior Architecture and Environmental Design

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September 2025

This study explores the audiovisual perceptions of students in informal learning environments at the I.D. Bilkent University campus, with a particular focus on students diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). Using a grounded theory approach, semi-structured interviews (ISO/TS 12913-2:2018 Method C) were conducted to gain in-depth insight into how students experience and interpret their sensory surroundings. A total of 20 participants, which are equally divided between ADHD and non-ADHD students, were selected through convenience sampling. Four informal learning environments on campus were selected based on their diverse acoustic and spatial characteristics, supporting both individual study and social interaction. To complement the qualitative data, structured questionnaires (Method A) and in-situ sound level measurements (LAeq) were also employed to capture perceptual attributes and objective acoustic conditions. The findings indicate that students diagnosed with ADHD evaluated informal learning environments more negatively, describing them as chaotic, annoying, and less calming. In contrast, non-ADHD participants reported greater comfort and satisfaction, particularly in acoustically balanced spaces. Significant perceptual differences between the two groups were observed in specific environments like the dormitory and Faculty of Fine Arts. Moreover, natural sounds were positively correlated with feelings of calmness, while human and technological noises contributed to negative perceptions. These perceptual differences highlight the need for inclusive design strategies that consider neurodiversity in learning environments.

Keywords: ADHD, Audio-Visual Perception, Grounded Theory, Indoor Soundscape, Learning Environments, Neurodiversity

# ÖZET

## DİKKAT EKSİKLİĞİ VE HİPERAKTİVİTE BOZUKLUĞU (DEHB) OLAN ÖĞRENCİLERİN RESMÎ OLMAYAN ÖĞRENME ORTAMLARINDAKI GÖRSEL-İŞİTSEL ALGILARININ ARAŞTIRILMASI

Şahmaran, Ceren

Yüksek Lisans, İç Mimarlık ve Çevresel Tasarımı Bölümü

Tez Danışmanı: Dr. Öğr. Üyesi Semiha Yılmazer

Eylül 2025

Bu çalışma, İ.D. Bilkent Üniversitesi kampüsündeki resmi olmayan öğrenme ortamlarında öğrencilerin görsel-işitsel algılarını incelemekte ve özellikle Dikkat Eksikliği ve Hiperaktivite Bozukluğu (DEHB) tanısı konmuş öğrenciler üzerinde yoğunlaşmaktadır. Grounded Teori yaklaşımı benimsenerek, öğrencilerin duyusal çevrelerini nasıl deneyimlediklerini ve yorumladıklarını derinlemesine anlamak amacıyla yarı yapılandırılmış görüşmeler (ISO/TS 12913-2:2018 standardı Yöntem C'ye göre gerçekleştirilmiştir. Ayrıca, nitel verileri desteklemek amacıyla yapılandırılmış anketler (Yöntem A) ve yerinde yapılanA ağırlıklı Eşdeğer ses düzeyi ölçümleri (LAeq) kullanılarak hem öznel hem de nesnel akustik veriler toplanmıştır. Bu çalışma Müsaitlik yöntemi (Convinience sampling method) kullanılarak eşit sayıda 10 DEHB'li ve 10 DEHB'siz olmak üzere toplamda 20 katılımcı ile gerçekleştirilmiştir. Kampüs içerisindeki, bireysel çalışmaya ve sosyal etkileşime olanak sağlayan çeşitli akustik ve mekânsal özelliklere sahip dört resmi olmayan öğrenme alanı araştırmaya dahil edilmiştir. Sonuçlar, DEHB'li öğrencilerin duyusal uyarıcılara karşı daha hassas olduklarını ve ortamları daha kaotik, dikkat dağıtıcı ve daha az dinlendirici olarak algıladıklarını göstermiştir. Buna karşılık, DEHB’siz katılımcılar aynı ortamları daha olumlu değerlendirmiş ve daha yüksek düzeyde konfor ve memnuniyet bildirmiştir. Bu algısal farklılıklar, öğrenme ortamlarının tasarımında nöroçeşitliliği göz önünde bulunduran kapsayıcı yaklaşımların gerekliliğine işaret etmektedir.

Anahtar Kelimeler: DEHB, Görsel-İşitsel Algı, Grounded Teori, İç Mekan İşitsel Peyzajı, Öğrenme Ortamları, Nöroçeşitlilik

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They have never left me alone, and their friendship has been a constant source of joy, comfort, and belonging throughout these years.

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| | |
|---|---|
| dB | Decibel |
| dBA | A-weighted decibels |
| GT | Grounded Theory |
| ILEs | Informal Learning Environments |
| HVAC | Heating, ventilation, and air conditioning |
| ISO | International Organization for Standardization |
| ADHD | Attention Deficit and Hyperactivity Disorder |
| PAQ | Perceived Affective Quality |
| MI | Multisensory Integration |
| SPL | Sound Pressure Level |
| STI | Speech Transmission Index |
| SEM | Structural Equation Modelling |
| T30 | Reverberation time, the first 30 dB of sound decay |
| VR | Virtual reality |

# CHAPTER I

# INTRODUCTION

The concept of the soundscape first emerged in the late 20th century, initially described as the totality of sounds forming an auditory environment. R. Murray Schafer defined the soundscape as any auditory environment, whether real or abstract, particularly when perceived as an environment (Schafer, 1993). Subsequently, ISO 12913-1 (2014) codified the idea, defining soundscape as the acoustic environment as perceived, experienced, and interpreted by individuals or groups in a given context (Nah et al., 2017). While earlier studies' attention predominantly centered on outdoor and urban contexts—such as public parks, open squares, and bustling commercial areas—more recent research has expanded toward the study of indoor soundscapes. This shift has encompassed a wide variety of settings: educational spaces such as classrooms (Çankaya, 2016) and study environments (Acun & Yilmazer, 2018); open-plan offices (Acun & Yilmazer, 2018; Sahin & Yilmazer, 2020); mosques (Yilmazer & Acun, 2018); museums (Acun & Yilmazer, 2019; Orhan & Yilmazer, 2021); hospitals (Yilmazer & Uğurlu, 2023; Alimadhi & Yilmazer, 2025); restaurants (Syed & Yilmazer, 2023); and residential spaces (Chen et al., 2023). Within the educational context, the indoor soundscape perspective has demonstrated the necessity of examining not only traditional classrooms but also a broader spectrum of learning environments. Among these are informal learning environments (ILEs), which operate as extensions of formal education (Dugdale, 2009). Such spaces as libraries, cafés, lounges, and other communal study areas facilitate self-directed study, collaboration, and the exchange of ideas outside the structured classroom framework. Although often associated with contemporary educational models, informal learning has a long history of contributing to knowledge development and student engagement (De Grip, 2024). What distinguishes these environments is their flexibility in sensory, spatial, and social dimensions, allowing for a more adaptive and personalized learning experience. This adaptability becomes especially relevant for learners with specific needs, including those with neurodevelopmental conditions such as Attention Deficit and Hyperactivity Disorder (ADHD). ADHD affects a notable proportion of both children and adults worldwide, with symptoms typically involving varying degrees of inattention, hyperactivity, and impulsivity (Wilens & Spencer, 2010). Across both formal and informal study environments, individuals continuously process streams of auditory and visual information. For people with ADHD, however, this sensory processing may differ markedly from that of their peers. Research has shown that atypical sensory responses are common among adults with ADHD, often manifesting as heightened sensitivity to environmental stimuli (Kooij & Bijlenga, 2014). By examining informal learning environments (ILEs), this study explores sensory perception and environmental experience, highlighting how auditory and visual environments impact learning for students with ADHD.

### 1.1 Aim and Scope

The primary aim of this study is to explore how students with and without Attention Deficit Hyperactivity Disorder (ADHD) perceive the acoustic and visual environments of informal learning environments (ILEs) on a university campus. By adopting a comparative approach, the study seeks to understand differences and similarities in the environmental perceptions of neurotypical and neurodivergent students

The research is grounded in the ISO/TS 12913-2:2018 standard, utilizing both Method A (structured questionnaire) and Method C (narrative interview) to explore subjective experiences. Additionally, in-situ measurements of the equivalent continuous A-weighted sound pressure level (LAeq) were conducted to correlate objective acoustic parameters with subjective evaluations. A mixed-method approach is employed: quantitative analysis reveals patterns in perceived affective quality (PAQ), while qualitative analysis using grounded theory provides deeper insights into the lived experience of sensory engagement.

The scope of the study is limited to four informal learning environments at Bilkent University, each offering distinct architectural and environmental characteristics. These spaces include (1) the Dormitory 77 study area, (2) the Fine Arts Building common area, (3) the Faculty of Science Building, and (4) Library Block B. The participant group comprises an equal number of students diagnosed with ADHD and their non-ADHD peers, allowing for comparative analysis across user groups and environmental contexts.

Through this research, the study aims to contribute to a more inclusive understanding of learning environments by highlighting the sensory and perceptual challenges faced by neurodivergent students who have ADHD, ultimately informing future visual and acoustic design strategies in educational settings.

## 1.2 Thesis Structure

This thesis is structured into six main chapters. The first chapter, Introduction, presents the background and motivation of the study, emphasizing the significance of investigating audio-visual environmental perception in informal learning environments (ILEs), particularly among students with and without ADHD. It defines the scope, research objectives, and outlines the structure of the thesis.

The second chapter, Literature Review, is divided into three main sections. The first section introduces the concept of soundscapes, referencing the ISO/TS 12913-1, -2, and -3 standards, and reviewing prior research on indoor soundscapes. The second section focuses on the relationship between learning environments and soundscapes, discussing both formal and informal learning settings. The third section explores neurodiversity in educational contexts, specifically addressing the developmental and cognitive characteristics of ADHD and the known impacts of soundscapes on students with ADHD.

Chapter three, Method, details the research design. It presents the research questions, explains the selection criteria for the four ILSs studied on Bilkent University campus, and describes their spatial, acoustic, and visual characteristics. The chapter outlines the methods for in-situ LAeq measurement and participant recruitment (including ADHD diagnosis verification) and describes the data collection tools: structured questionnaires for Method A and narrative interviews for Method C. It further explains the application of the grounded theory method in coding interview data and the statistical procedures used to analyze questionnaire results.

Chapter four, Results, presents the findings of the study. It includes a conceptual framework developed through thematic coding of Method C interviews and provides statistical results from Method A questionnaires. Spearman's correlation and Kruskal-Wallis tests are used to evaluate relationships between affective responses and environmental features. Comparisons between ADHD and non-ADHD groups are highlighted.

Chapter five, Discussion, interprets the findings in relation to the research questions and existing literature. It is divided into two parts: the first part discusses differences in perception between ADHD and non-ADHD students, including sensory sensitivity and coping strategies. The second part contextualizes these findings within the broader soundscape and environmental psychology literature, offering reflections on the inclusivity of learning environments.

The final chapter, Conclusion, summarizes the key insights of the research, highlights its limitations, and suggests directions for future studies, especially regarding the design of neuro-inclusive informal learning spaces.

# CHAPTER II

# LITERATURE REVIEW

This chapter reviews the literature on soundscapes, focusing on their relevance to learning environments. It introduces the concept and evaluation methods of soundscapes, followed by previous research on indoor soundscapes in both formal and informal settings. The role of audio-visual perception in shaping environmental experience is discussed, along with its implications for students. Finally, the chapter examines neurodiversity in learning contexts, with particular attention to ADHD and the influence of soundscapes on individuals with this condition.

## 2.1 Soundscapes

The concept of the soundscape was first introduced by R. Murray Schafer in the 1960s (Schafer, 1969). Later, the ISO 12913-1 standard (ISO 12913-1, 2014) defined soundscape as the "acoustic environment as perceived and understood by a person or people in context," where context refers to the interaction between the individual, their activity, and the surrounding environment. This implies that both the nature of the task and the characteristics of the physical setting influence how different individuals perceive, interpret, and respond to the sounds around them. The soundscape approach was subsequently developed to investigate the relationship between acoustic environments and human well-being, with particular attention to how people perceive and experience these environments. While much of the existing research has concentrated on soundscapes in expansive urban and outdoor settings, the ISO definition underscores the importance of “context,” thereby extending its applicability to buildings and other indoor environments (Aletta & Astolfi, 2018). Furthermore, it is mentioned that indoor soundscapes exhibit greater complexity than urban soundscapes, attributed to their intricate nature (Jo & Jeon, 2022). As a result, the study of soundscapes has gained increasing importance, focusing on the ways individuals perceive and interact with their auditory surroundings (Acun, 2021). In this context, the soundscape is understood as a subjective concept that reflects how people relate to and interpret the acoustic environment (Aburawis & Dokmeci Yorukoglu, 2018; Brooks et al., 2014; Kang et al., 2017; Yang & Kang, 2013). ISO 12913-1 (2014) outlines this connection within the context of the soundscape framework (Figure 1).

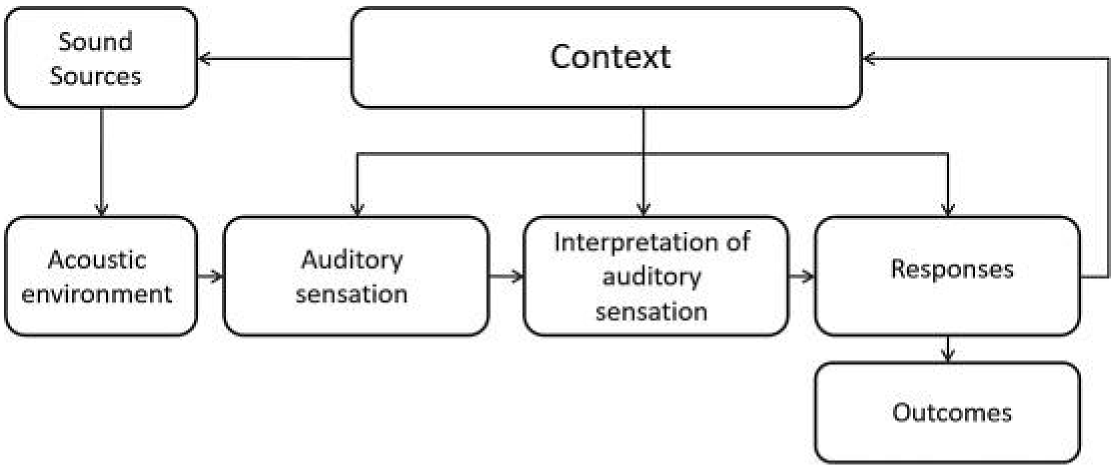


Figure 1. Soundscapes Framework created by ISO/TS 12913-1 (2014)

## 2.2 Previous Studies on Indoor Soundscapes

The predominant focus of soundscape research has been on urban environments, while indoor environments have received comparatively limited attention.

Nonetheless, a range of indoor environments exists, each fulfilling distinct functions and presenting entirely different acoustic settings (Acun & Yilmazer, 2019). Even though inquiries into soundscapes within indoor environments remain somewhat restricted, they are progressively gaining attention as a crucial subject for the creation of healthier and more comfortable indoor spaces (Torresin et al., 2020b; Aletta and Astolfi, 2018). Consequently, it is essential to give equal attention to indoor soundscapes alongside urban soundscapes. A variety of research has been carried out across different indoor environments, each characterized by unique contexts, including educational institutions, office spaces, cultural and public spaces, religious facilities, libraries, healthcare environments, and residential environments, among others. Evaluating each indoor environment requires customized assessments due to these contextual variations.

***Educational Settings***

Acun and Yilmazer (2018) studied the soundscapes of four open study areas at Bilkent University, with the objective of analyzing student satisfaction, coping strategies, and perceptual aspects. A sample of 120 individuals, ranging in age from 18 to 26 and predominantly consisting of undergraduate students, was examined using questionnaires alongside concurrent in-situ sound level assessments. The survey concentrated on demographic data, sources of sound, levels of satisfaction, perceived loudness, and coping mechanisms, in addition to perceptual dimensions assessed via semantic differential scales. The findings indicated that although there were considerable variations in sound levels (spanning from 47.2 to 62.2 dB(A)), no significant differences were observed in perceived loudness or soundscape satisfaction across the study areas. Sounds produced by humans, especially verbal communication and laughter, were the most commonly encountered and notably disruptive, impacting focus. The strategies employed for managing the situation encompassed the use of earphones, changing locations, or exiting the study environment, with a limited inclination towards disrupting sound sources. Through factor analysis, three distinct perceptual dimensions were identified: sensation, activity/communication, and functionality. The results emphasize the significance of context in the perception of soundscapes, indicating that sound levels by themselves do not determine satisfaction. This investigation highlights the intricate nature of indoor sound environments and underscores the necessity for additional inquiry to enhance evaluative techniques and comprehend various contexts.

Çankaya and Yılmazer (2022) explored classroom and laboratory soundscapes in a high school setting. The study revealed that students' auditory perceptions were influenced not just by sound levels but by the context of the sounds, such as the activity or lecture type.This study examined the auditory perceptions of high school students in both classroom and computer laboratory settings. A mixed-method approach was employed, wherein quantitative data were collected via surveys (n=117) and sound level measurements, complemented by qualitative insights obtained from semi-structured interviews (n=50). The measurements comprised LAeq, T30, and STI to assess the acoustical conditions, indicating that sound levels frequently surpassed the recommended thresholds, which could have implications for students' comfort and performance. The analysis underscored the significance of context in auditory perception, revealing that preferences fluctuate depending on the task and sound intensity. For example, learners were able to endure ambient noise while engaging in hands-on activities; however, they perceived elevated sound levels as disruptive during instructional sessions. Human and electro-mechanical sounds exhibited varying perceptions across different environments, where laughter was regarded favorably in classrooms, yet received a less positive reception in laboratories. The findings indicated that adverse sound environments may result in diminished motivation and concentration, whereas favorable sound environments facilitated enhanced engagement. The results highlight the necessity for enhanced acoustic design within learning environments, focusing on the integration of natural sound, suitable sound levels, and adaptable layouts to improve educational outcomes.

### *Office Environments*

Acun and Yilmazer (2018) sought to investigate the subjective reactions of employees to soundscapes within open-plan office environments and to construct a conceptual framework through a grounded theory methodology. Data were gathered in two distinct office environments, specifically reflecting the fields of architecture and engineering. In-depth, semi-structured interviews were carried out with a total of 49 participants, comprising 21 males and 26 females, across both office locations. This qualitative data collection was further enhanced by in-situ acoustic measurements (LAeq) and simulations performed using Odeon Room Acoustics Software. Interviews elucidated the ways in which auditory sources such as speech, mechanical noise, and contextual elements shaped individuals' perceptions of the sound environment. Participants indicated that unforeseen or disruptive auditory stimuli adversely impacted their task performance, frequently resorting to coping mechanisms such as utilizing headphones, acclimatizing, or separating themselves. It is noteworthy that diminished sound levels also resulted in discomfort, prompting considerations regarding privacy and collaborative efforts. The research findings indicate that individual and contextual factors significantly influence both positive and negative perceptions of soundscapes, highlighting the importance of incorporating soundscape considerations into office design. The results enhance the understanding of soundscape theory and provide valuable guidance for improving acoustic conditions in professional settings.

Sahin and Yimazer (2020) conducted a study examining the perception of indoor soundscapes across three distinct open-plan office environments: real (RE), recorded virtual (VE_Rec), and virtual (VE). The study carried out at Demay Architecture in Ankara sought to assess the reliability of measuring soundscape quality in virtual environments in accordance with ISO 12913-2:2018. A total of ninety participants were allocated into three distinct groups of thirty, with each group subjected to a specific environment.The RE group engaged with the real office environment by traversing a designated path that encompassed ten specific locations in a quiet manner. The VE_Rec group engaged with a recorded video of the identical route to replicate a virtual soundwalk, whereas the VE group participated in a digitally modeled animation of the office environment. All participants completed a questionnaire aligned with ISO/TS 12913-2:2018 Method A, which was developed to evaluate soundscapes via eight perceptual attributes. The findings demonstrated that the real environment (RE) was regarded more favorably compared to the virtual settings. RE received higher ratings for being “pleasant” and “calm,” whereas VE_Rec and VE were characterized as more “annoying” and “chaotic.”

Jo and Jeon (2022) evaluated open-plan offices using virtual audio-visual simulations. This research examined the interactions between audio-visual environments and their impact on the perception of indoor soundscapes, with the aim of designing enjoyable open-plan office spaces. A total of thirty-four participants, ranging in age from 20 to 33 years, were subjected to 24 distinct virtual office environments, which integrated diverse acoustic and visual stimuli through the application of virtual reality (VR) technology. The acoustic stimuli were systematically modeled through computer simulations, integrating a range of sound levels and reverberation conditions. In parallel, the visual stimuli comprised layouts characterized by differing window-to-wall ratios and views, categorized as either pleasant or unpleasant. This research sought to assess the perceived affective quality, job satisfaction, and performance on tasks within these settings. The findings indicated that visually appealing, well-structured, and expansive layouts contributed to increased visual satisfaction and a sense of privacy, whereas quieter and less reverberant acoustic environments facilitated improved task performance. The results underscored a notable interaction between visual and auditory elements, indicating that visual characteristics can affect sound perception and general contentment. Nevertheless, conflicting relationships were identified among visual characteristics, job satisfaction, and task performance, indicating a potential trade-off between psychological comfort and productivity. This research offers significant findings for the development of balanced OPOs, suggesting environments characterized by reduced sound levels (under 48 dB), increased visual openness, and sufficient personal space to enhance employee satisfaction and productivity. The findings presented herein provide a valuable framework for the development of cohesive, multi-sensory office settings.

***Cultural and Public Spaces***

Acun and Yilmazer (2019) investigated the impact of soundscapes on visitor experiences within the historic context of Çengelhan Caravanserai, currently known as the Rahmi Koç Museum. Through the application of grounded theory and conducting interviews with 15 participants, the study revealed that expectations and preferences significantly influenced the interpretation of soundscapes. Visitors typically favored quiet environments; however, they valued soundscapes that aligned with exhibit themes, exemplified by the enhancement of authenticity through blacksmith sounds. The architectural design of the museum, characterized by its historic stone walls and wooden flooring, along with carefully curated auditory components, fostered an immersive environment. Positive auditory environments enhanced visitor involvement, cultivating a feeling of temporal immersion. Nonetheless, discrepancies, including inconsistent audio levels, resulted in considerable frustration and distraction. Similarly, Orhan and Yilmazer (2021) found that visitors preferred soundscapes that aligned with the thematic context of the museum.

Xiao and Aletta (2016) explored acoustic comfort in a modern public library, demonstrating that sound sources and architectural layouts shaped user perceptions independently of measured sound levels.This research, carried out by Jieling Xiao and Francesco Aletta, examined acoustic comfort within the Library of Birmingham through the lens of a soundscape methodology. This study sought to examine the extent to which the design of the library facilitates activities like reading and writing through an assessment of its acoustic environment. The methodology involved conducting soundwalks across four primary floors, during which twelve undergraduate architecture students evaluated sound pressure levels, categorized sound types, and assessed the perceived quality of the acoustic environment. Individuals in the age range of 20 to 23 collected both objective measurements and subjective assessments, evaluating the suitability of soundscapes for library purposes.The findings indicated that the acoustic environment of the library was primarily shaped by human-generated sounds, exhibiting variations in soundscape quality among the various floors. The arrangement and intended use of environments had a considerable impact on individuals' perceptions of acoustic comfort, surpassing the influence of the actual sound pressure levels. For instance, environments intended for collaborative engagement were determined to be less acoustically appropriate for solitary tasks such as studying. The research findings indicate that the arrangement of space plays a vital role in attaining acoustic comfort. It suggests approaches such as visual zoning and adaptable layouts to improve user experience in open-plan libraries.

***Religious Spaces***

Yilmazer and Acun (2018) investigated the soundscapes of mosques, identifying a strong connection between place identity and soundscape elements. This research investigates the indoor sound environment of Hacı Bayram Mosque, a significant historical religious site located in Ankara, Turkey, employing a Grounded Theory (GT) methodology. The mosque, situated in a district abundant in cultural heritage, functions as a center for both religious and social activities. The study engaged 15 male participants, aged between 36 and 60, who were interviewed in the historic square of the mosque to gain insights into their auditory perceptions. Participants were chosen due to their prior experience with the mosque, having previously spent time within its premises before the interviews took place. The primary results indicate that spatial function plays a crucial role in shaping soundscape expectations and preferences. The auditory environment was predominantly linked to serenity, spirituality, and enigma, enhancing the identity of the location in a favorable manner. Nevertheless, external disturbances from vehicular movement and commercial operations interfered with the experienced tranquility. Participants expressed a general appreciation for indoor broadcasts of Quran recitations and hymns; however, their sentiments regarding the extension of these broadcasts to outdoor areas were varied.

Algargoosh et al.'s (2022) study uses a mixed-methods approach to investigate how acoustic environments in spaces of worship affect human emotion and experience. Researchers used a combination of wet (reverberant) and dry (anechoic) recordings of hymns and chants, along with 360° images of four places of worship, to expose 20 volunteers from a variety of cultural backgrounds to eight stimuli. Emotional reactions were assessed using physiological markers including heart rate and electrodermal activity as well as self-reports. According to the results, reverberant acoustic environments increased the intensity of emotions, especially calming and spiritual ones, and audiovisual congruency improved spatial immersion also. Knowledge of the sound and the space's cultural background enhanced the emotional effect. In order to create immersive and culturally resonant places, our studies emphasize the significance of integrating acoustics into architectural design.

### *Healthcare Environment*

Studies in hospitals, such as Uğurlu and Yilmazer (2021), have explored the audio-visual perception of patients in clinics. Interventions like adding natural sounds were shown to enhance positive soundscape experiences. This research investigates the impact of auditory and visual stimuli on the comfort levels of patients in the waiting areas of an oncology polyclinic located at Ankara City Hospital. A total of 66 voluntary outpatients were involved in the study, with data gathered from three separate locations: the reception area, courtyard, and corridor. The quantitative methods employed comprised Equivalent Continuous A-Weighted Sound Level (LAeq) measurements, binaural recordings, and 360° photographs, which were subsequently analyzed utilizing MATLAB. Data of a qualitative nature were collected via semi-structured interviews conducted with 20 participants and subsequently analyzed employing Grounded Theory methodology. The findings revealed that the courtyard area was regarded as the most tranquil and enjoyable, with sound sources primarily stemming from human interactions and technological activities. The research emphasized the importance of creating hospital settings that harmonize auditory and visual components to improve patient comfort and overall well-being.

Another study can be mentioned that Alimadhi and Yilmazer (2025) examines how biophilic design—integrating natural elements into built environments—affects audio-visual perception and psychological restoration in two oncology waiting areas at Ankara City Hospital. Using both field surveys and controlled lab simulations, the researchers compared a more biophilic space (WA1) with courtyard access and nature imagery to a less biophilic one (WA2). Participants assessed the spaces in terms of biophilic quality, soundscape perception, and emotional restoration. While WA1 was perceived as significantly more biophilic in the real-world setting, no such difference emerged in the lab. Both environments were described as acoustically unpleasant—annoying, chaotic, and eventful—and showed no significant differences in how restorative or emotionally supportive they felt. The findings suggest that while biophilic elements can enhance perceived environmental quality, their impact on emotional restoration may be limited in noisy healthcare settings unless more immersive or robust natural features are incorporated.

***Residential Spaces***

Chen, Kang, and Ma (2023) investigated healthy indoor acoustic environments in residential buildings, focusing on the perspectives of the occupants by employing  a mixed-method approach . The study comprised qualitative interviews conducted with 35 respondents, which were analyzed utilizing grounded theory. This was followed by a quantitative survey involving 720 participants, analyzed through structural equation modeling. The participants exhibited a diverse range of ages and professional backgrounds, having been recruited through both social media platforms and in-person approaches. The findings revealed nine essential components, such as Attachment, Privacy, Autonomy, and Controllability, with Controllability exhibiting the most significant influence (effect size = 0.475) on health assessments by alleviating negative emotions, physical discomfort, and behavioral disturbances associated with noise. The influence of attachment was notably significant among younger adults, contributing to increased comfort and positive emotional experiences. Women and younger individuals exhibited more intricate evaluation processes in contrast to men and older adults.

The research conducted by Devos et al. (2019) investigated the creation of supportive soundscapes for nursing home residents diagnosed with dementia, with the objective of improving their well-being and alleviating behavioral and psychological symptoms associated with dementia. The study, carried out in nursing homes, utilized a collaborative methodology that engaged caregivers and family members in the development of customized soundscape interventions. Acoustic stimuli, encompassing natural sounds, music, and environmental cues, were incorporated into nursing home settings to facilitate mood regulation, improve perceived safety, and elicit particular behavioral responses.
The findings underscored the capacity of soundscapes to foster a favorable environment and enhance the quality of life for residents. Participants indicated a soothing influence, increased awareness, and improved social engagement among residents. The interventions exhibited a promising capacity to diminish reliance on pharmacological treatments while simultaneously enhancing the working conditions for staff members. This framework highlights the necessity for tailored soundscape design, considering the distinct requirements and cognitive challenges faced by individuals with dementia, and presents a potentially effective non-pharmacological approach to enhance dementia care.

The findings from these studies collectively highlight the significance of context in influencing perceptions of indoor sound environments. Through the integration of quantitative and qualitative methodologies, researchers have offered significant insights into the design of soundscapes that address users' needs and preferences.

## 2.3 Learning Environments and Soundscape

Interest in the nature of learning has grown steadily over recent decades, with researchers increasingly exploring its many forms and contexts (Belanger, 2011). This shift has led researchers to consider not only teaching methods but also the physical and social environments in which learning takes place. Among these, physical environments have attracted particular attention, as they are now recognized as key contributors to the overall learning experience. In educational settings, the sound environment has emerged as a significant aspect of this discussion, influencing not only comfort but also students' ability to concentrate, collaborate, and engage effectively with their studies (Hong et al., 2022; Li et al., 2021). Therefore, the design of educational spaces is widely acknowledged as one of the most influential factors shaping students' learning outcomes. A well-designed environment does more than simply accommodate learning activities; it actively shapes the habits, beliefs, and values of its users, fostering a culture that supports both academic and personal growth (Shmis et al., 2014). Consequently, understanding the interplay between spatial design, the acoustic environment and visual quality, and student experience has become increasingly important in efforts to create inclusive, supportive, and adaptable learning environments.

### 2.3.1 Formal Learning Environments

Formal learning occurs as a result of experiences in an education or training institution, with structured learning objectives, learning time, and support, which leads to certification (Cedefop, 2009). It occurs where an institution is established based on the official criteria set by the Ministry of Education, aimed at fulfilling individual, social, and environmental needs. It provides an ethical, scientific, safe, healthy, vibrant, and compassionate environment with a collective identity, while also implementing the programs approved by the Ministry of Education at designated academic levels (Planning and Budget Organization, 2016, 5). These spaces are considered ideal environments for establishing social interactions (Mansouryar & Jalalian, 2017, 67). The educational environment is defined as everything that happens within a classroom, department, faculty, or university. Perception of the educational environment is directly related to individuals' motivation, satisfaction, and effective learning (Patil & Chaudhari, 2016, 281). Educational spaces encompass all indoor and outdoor spaces, as well as all other areas and elements associated with the school (Lotfata, 2008, 82). Additionally, the spatial conditions of the physical environment significantly impact the teaching and learning process (Widiastuti et al., 2021, 503). While formal learning environments provide structured settings that foster academic and social development, learning is not confined to these spaces. Informal learning environments also play a crucial role in shaping knowledge, skills, and experiences beyond the boundaries of formal education.

### 2.3.2 Informal Learning Environments

Informal learning environments refer to out-of-classroom spaces where learning and knowledge exchange take place, ranging from libraries and computer centers to cafés, lounges, and residences (Dugdale, 2009). Such spaces may be purposefully designed to promote a sense of openness and freedom, thereby encouraging student interaction, active participation, and independent study (Berman, 2020). However, as Dugdale (2009) notes, they may also emerge organically as students repurpose existing areas for learning-related activities. However, there is a range of challenges in the adequate evaluation of informal spaces, particularly as their use varies at different times of day and night and throughout the academic year. Making effective use of all these spaces depends on a wide range of decisions. For instance, creating a hint of privacy through architectural elements enhances the functionality of informal learning spaces and promotes better concentration in an active environment. (Poutanen 2013, 2015; Poutanen and Syvänen 2014). Therefore, design considerations must address how to balance multiple functions within a shared space, how to leverage the rhythm of space usage, which is an important aspect in educational environments, to support informal learning, and how to create environments that accommodate informal learning alongside other activities.

### 2.4 Neurodiversity in Learning Environments

The principle of inclusive education emphasizes the importance of educating all students, including those with special needs, such as developmental disorders, within the most typical context available (UNESCO, 1994). According to the American Psychiatric Association, neurodevelopmental disorders consist of several conditions defined by challenges in personal, social, academic, and occupational functioning that emerge during the developmental period (American Psychiatric Association, 2013). Instances of diagnoses classified within the neurodevelopmental disabilities category encompass autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), intellectual disability, and specific learning disabilities (Francés et al., 2022). It  is argued that neurodivergent learners encounter considerable challenges in accessing higher education, which has traditionally been viewed as a domain for the privileged. Although there is a growing enrollment of students from various backgrounds in universities, individuals from more advantaged backgrounds continue to exhibit higher rates of advancement to higher education (Nash-Luckenbach & Friedman, 2024). Individuals with neurodiverse conditions ought to be included in higher education, as barriers that hinder their participation are frequently outside their control. It is imperative for higher education institutions to offer customized support and accommodations to facilitate the success and full potential of these learners. (Ker & van Gorp, 2023). The inclusion of informal learning experiences within formal education frameworks enhances engagement and offers valuable outcomes for all learners, regardless of their disabilities. These benefits encompass enhancements in self-perception, improved adaptive behaviors, stronger friendship development, and an overall elevation in quality of life (Merrells et al., 2018; Shields et al., 2015).

### 2.4.1 Developmental and Cognitive Characteristics of Attention Deficit and Hyperactivity Disorder (ADHD)

Attention-deficit/hyperactivity disorder (ADHD) is classified as a neurodevelopmental disorder characterized by differing degrees of inattention, hyperactivity, and/or impulsivity (Schulze et al., 2022), which are called the Predominantly Inattentive Type, the Predominantly Hyperactive-Impulsive Type, and the Combined Type, and it encompasses individuals exhibiting both inattentive and hyperactive/impulsive characteristics (American Psychiatric Association, 2000). It is seen in approximately 4% to 12% of children in school settings globally, with research and epidemiological data indicating that 4% to 5% of individuals in college and adulthood are affected by this condition (Kessler et al., 2006; Polanczyk et al., 2007). However, it is also asserted that there are distinctions between ADHD in adulthood and ADHD in childhood. For instance, research indicates that adults diagnosed with ADHD exhibit a reduced frequency of hyperactivity symptoms compared to their child counterparts (Faraone et al., 2006). Specifically, adults exhibiting ADHD or ongoing symptoms associated with it are more likely to report challenges related to inattention rather than hyperactivity and impulsivity. This suggests that inattention is a significant characteristic of adult ADHD (Biederman et al., 2009; Wilens et al., 2009). The article also supports the idea that people with children demonstrated the poorest performance in sustained attention, rapid serial naming of figures and colors, comprehension of written instructions, word dictation, number comparison, arithmetic problem-solving, visual working memory, and long-term memory (Yáñez-Téllez et al., 2012). Given these cognitive and attentional difficulties, it becomes important to consider how students with ADHD interact with and respond to the sensory qualities of the environments.

### 2.4.2 The Influence of Soundscapes on Multisensory Processing in Students with Attention Deficit and Hyperactivity Disorder (ADHD)

Students with ADHD often experience sensory processing differences that heighten their sensitivity to physical and social environments, including emotional, visual, and auditory stimuli (Alizadeh et al., 2023). This increased sensitivity can make it challenging to sustain attention in environments with multiple sensory inputs, ultimately affecting both cognitive performance and mental well-being. For instance, the flicker and low humming noise produced by fluorescent lighting have been shown to cause visual and auditory discomfort, trigger hyperactive behaviors, and hinder learning. Studies by Higginbotham and Bartling (1993) and Adams et al.

(2009) found that auditory and visual distractions significantly reduced short-term recall and continuous performance in individuals with ADHD compared to controls. Such difficulties are closely connected to differences in multisensory integration (MI), the process by which auditory and visual information is combined to form a unified perception (Stein & Wallace, 1996). MI engages the parietal and occipital cortical regions, which often display structural and functional differences in ADHD populations (Makris et al., 2007; Brandwein et al., 2011; Proal et al., 2011). In learning contexts, where auditory and visual stimuli frequently occur together, effective MI enables coherent perception and accurate stimulus recognition (Foxe & Molholm, 2009). However, attentional deficits and altered neural processing in ADHD can disrupt this integration, making sensory-rich environments such as informal learning spaces particularly demanding. Although these perceptual differences can substantially affect both academic engagement and daily functioning, they continue to be underrepresented in research on adults with ADHD (McCracken et al., 2020). By addressing this gap, the present study aims to provide new insights into how the auditory and visual environments influence the spatial perception, interact with the sensory processing and impact those students with ADHD.

# CHAPTER III

# METHOD

## 3.1 Design of the Study

This study adopts a qualitative approach based on the principles of grounded theory to explore students' perceptions in informal study spaces both visually and acoustically. The research focuses on groups of students: those with attention deficit and hyperactivity disorder (ADHD) and those without, with a total of 20 participants (10 with ADHD and 10 without). This research was carried out in four informal study environments located in the Bilkent University Campus, specifically in Dormitory 77, the Fine Arts Building, the library, and the Faculty of Science Building. These locations were identified due to their diverse acoustic properties and their common use as informal study spaces. The data collection process involves a combination of in-situ sound level measurements (LAeq) to measure the acoustic environment and structured questionnaires aimed at understanding participants' perceptions of the soundscape. Semi-structured interviews are also used to gain a deeper understanding of students' experiences, focusing on key themes such as sound sources, reactions to noise, coping strategies, and the influence of the physical environment. Thus, using the combination of both qualitative and quantitative data allows for a comprehensive exploration of how students with and without ADHD perceive and interact with their informal study spaces.

### 3.2 Research Questions

This study seeks to solve the following research questions:

1. How does the auditory environment influence the spatial perception of students with attention deficit and hyperactivity disorder (ADHD) in informal study environments?"
2. How does the visual environment influence the spatial perception of students with attention deficit and hyperactivity disorder (ADHD) in informal study environments?"
3. 3. What are the differences between the audio-visual environment and the student's perception of the audio-visual environment?

This study delves into students' perspectives on informal study environments, specifically examining the effects of these environments on students with attention deficit and hyperactivity disorder (ADHD).

### 3.3 Method

This study adopts a grounded theory approach to investigate students' audiovisual perceptions in informal study environments, with a particular focus on students with and without attention deficit and hyperactivity disorder (ADHD). The aim is to systematically categorize and establish a conceptual framework to understand how students with varying needs perceive their surroundings within the context of informal study environments. This study employs a qualitative approach to explore the effects of soundscapes. The research utilizes a narrative interview method as outlined in Method C of ISO/TS 12913-2:2018, focusing on open-ended questions to deeply understand participants' experiences and perceptions of soundscapes. The narrative interview method was selected for its alignment with the study's aim to explore the subjective and personal experiences of soundscapes. To further enrich the data, responses are gathered to evaluate the sound environment by using the ISO 12913-2 Method A questionnaire.  Methods A and C of ISO/TS 12913-2:2018 provide a validated framework that ensures the reliability and depth of the data collected.

### 3.3.1 Site

The study was conducted in İ.D. Bilkent University's informal study environments, which are four different informal study environments known for offering multifaceted environments for learning and social activities, including dormitories, the Fine Arts Building, the library, and the Faculty of Science Building. These areas are especially popular with students, allowing them to work comfortably both individually and in groups, and are also areas where they can socialize. For example, location A, Dormitory 77's study area, is located on the 1st floor and is a frequent destination at most times of the day, as it is adjacent to an area where students can sit and cook together. In addition, location B is located in the Faculty of Fine Arts Design and Architecture building. This area is also popular as it is located next to the Starbucks cafe, and is a place where students can get coffee or food as needed while studying. Additionally, location C is located in the Faculty of Science building. This area is preferred mostly by engineering and science major students and is also preferred by other students because it is an isolated area compared to other locations.

Finally, location D is located on the second floor of Bilkent University Library, Block B. In this area, while there are private study areas for groups, it is also one of the areas where students prefer to work together, especially during exam times, as it also has study areas free to talk, study, and discuss their topic.

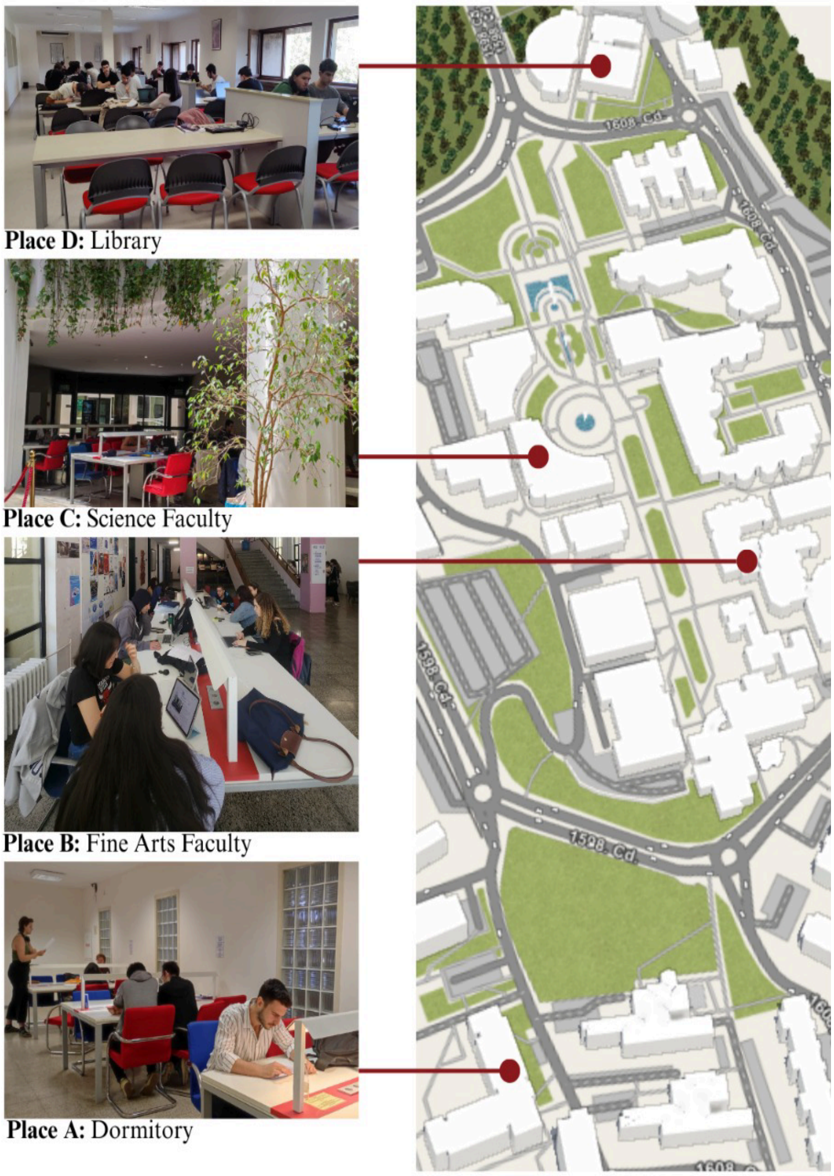


Figure 2: Informal learning environments of designated areas together with their corresponding buildings in the map

#### 3.3.1.1 Architectural Features

While selecting four different informal study spaces on the campus, it is valued that they have different architectural features and varied acoustic and visual components. For instance, location A, which is placed in Dormitory 77, is located on the first floor. Floor tiles are made of ceramic. Also, there is a glass brick side wall near the tables, and behind the study space there is a glass wall door, which makes a connection between the common dining area. The column in the middle of the study area, the ceiling, and the other walls are made from plaster and paint. For Location B, which is located in the Faculty of Fine Arts and Architecture, the floor material is granite, and the staircase, which is located in the middle of the space, has the same material. Walls and the ceiling finishes are made of plaster and paint besides the entrance wall. The entrance wall has huge openings made of glass. For Location C, it is located in the Faculty of Science. The study space is on the ground floor and situated in the middle of the floor.  The space is divided into two with an ornamental pool. Therefore, spread over a wide area. The floor is made of granite tiles, but the columns, walls, and ceiling are made of plaster and paint. For the last place, Location D, which is located at the library, is situated in B block nearby the multimedia room. The study space is circulated with private study rooms for four people. Therefore, there is no window opening towards the outside, but the room has a window itself. While the floor finish material is rubber, the walls, columns, and ceilings are made of plaster and paint.

### 3.3.1.2 Acoustic Environment

The informal study environments were selected in different locations at İ.D. Bilkent University. Therefore, the acoustic properties of the spaces vary from one another. A Zoom H4 sound recorder and a binaural microphone were used to collect in-situ measurements at a height of 120 cm to measure the acoustic environment in every chosen location. LAeq, an Equivalent Continuous A-Weighted Sound Level measure, was assessed according to ISO/TS 12913-3 recommendations. For instance, Location A is the study area in the common area of the dormitory where male and female students stay, consisting of two blocks. The primary sound sources of location A were mostly human-generated sound sources, such as the sounds of students laughing and talking next door for lunch and the sounds of people working in the dormitory dragging garbage bags while taking out the trash, and the footsteps of people going up and down the stairs. On the other hand, there are also non-human-generated sound sources, which are door sounds, the buzzing sound of the fluorescent lamp, and the sounds of other people working on their laptops.

For Location B, which is placed in the Faculty of Fine Arts and Architecture, the area is between Starbucks and the entrance of the building. Therefore, the area has various types of sounds, such as the sound of the coffee machine, the sound of the cashier, the sound of people ordering, the sound of the door, the sound of people studying together, and the sounds of people entering and leaving the classroom, which include both human and non-human-generated sounds. The frequency and density of the sounds at the location change according to the time of day. The morning and afternoon times of the day are noisier than the evening time.

For Location C, it is in the Faculty of Science Building. The building basically consists of classes, laboratories, and study areas. Because of the design of the building, it has a high gallery opening. Therefore, every sound, silent or loud, can be heard by echoing. That's why, people who are using the study area are trying to not make any noise, so they are whispering to each other. For this reason, non-human-generated sounds such as vending machines, coffee machines, and door opening and closing sounds are more in the foreground and consistent compared to human-generated sounds. The frequency and density of the sounds at the location also change for this place. For example, in class time, footstep sounds and talking and laughing sounds overshadow the non-human-generated sounds.

Lastly, location D is located in the main campus library B block on the second floor. The study space is near the multimedia room. Therefore, numerous humanized and non-humanized sounds are being created. To exemplify, due to its location in the library, the sounds of people explaining lessons to each other, laughter, the sound of pens falling to the floor, the movie sounds coming from multimedia rooms, the sound of doors opening and closing, and computer keyboard sounds are more common in location D. Unlike location B and C, this study area is more active after class time. This is because locations B and C are closer than location D to the classrooms.

#### 3.3.1.3 Visual Environment

Location A (Figure 3) is in the dormitory study area, which is located in the buffer zone between the bedrooms and the public kitchen area. The staircase leads to tables. The place has no windows, but there is a glass brick wall near the tables. Additionally, there is a column in the center of the room that does not obstruct the view. In this place, there are three tables, but three of them have both sides, and on every side there are three seats. According to my observation, students are not keen to sit shoulder to shoulder. This is why they often remove the middle seat, either by filling it with personal items or leaving it empty. Despite the table's dual sides, the design of the table lamp takes into account the average sitting eye height. Therefore, the person who studies on those tables does not look at the person's eyes directly.Furthermore, location B (Figure 4) is located in the Faculty of Fine Arts, which is placed at the entrance of the building. The study area has one long table, which also has two sides. Due to its proximity to the classroom and the Starbucks Cafe, the study area is nearly always occupied during class hours. One side of the table faces the Starbucks cafe's balcony, while the other faces the classrooms. Because of the Starbucks Cafe, the coffee queue reaches the study area most of the time. As a result, the study area is frequently crowded. Another factor contributing to the crowding is the location of the building's main staircase. This implies that the study area is situated in the main circulation area of the building.For location C (Figure 5), it is located in the Science Faculty. The study area is divided into two by the indoor pool in between. Thanks to the indoor greenery and the skylight on the ceiling, the space receives sufficient daylight. In addition, this two-story building gains a sense of spaciousness through the central courtyard, which is why it has become a popular spot for students.Finally, location D (Figure 6) is in the library. During exam periods, this study area is quite crowded. While it contains large tables designed for group work, there are also private glass-enclosed study rooms positioned around these tables. From the tables by the windows, it is also possible to see the greenery outside.

Figure 3: Panoramic photograph of Dormitory 77 Informal Learning Environment

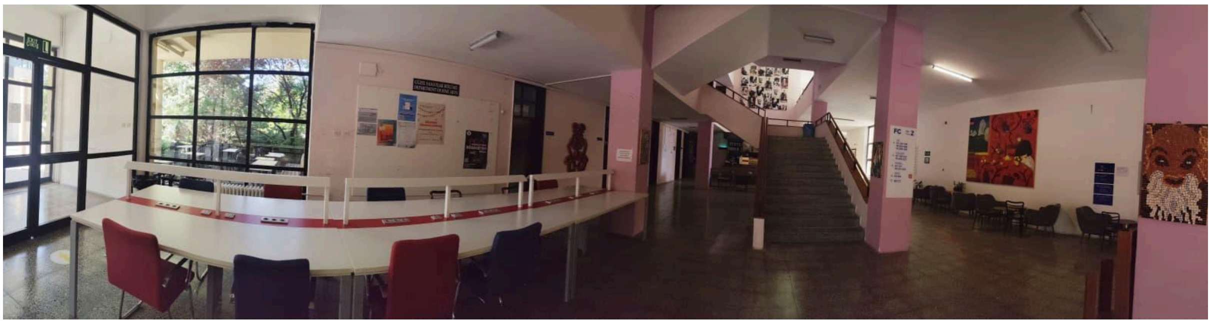

Figure 4: Panoramic photograph of Fine art Faculty Informal Learning Environment

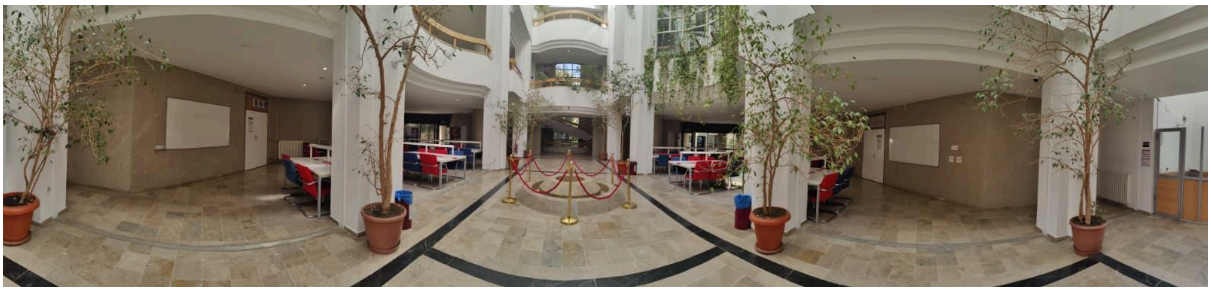

Figure 5: Panoramic photograph of Science Faculty Informal Learning Environment

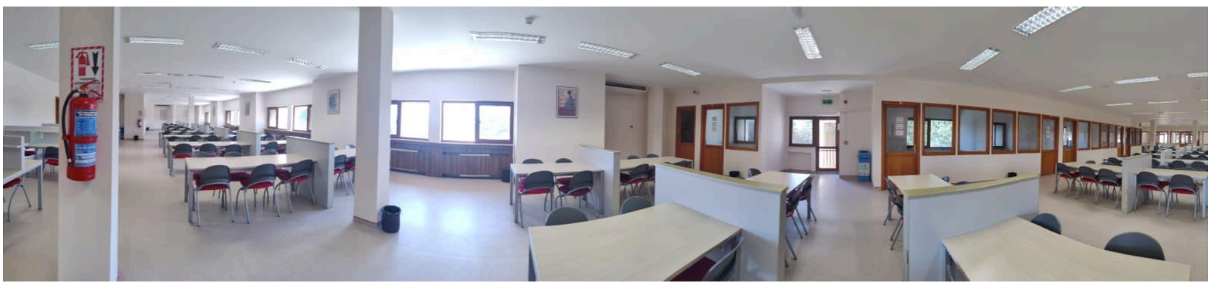

Figure 6: Panoramic photograph of Library Informal Learning Environment

### 3.3.2 Participants

The participants were selected by convenience sampling. 20 participants were selected for the study, evenly divided into two groups of 10: those with ADHD and those without. Demographic information such as age, gender distribution, and hearing ability is recorded to ensure a diverse sample reflective of the student population. There were 16 males and 16 females, and the age distribution is between 18 and 35 (mean age = 23.30; SD age = 2.75 years). All of the students participated in the semi-structured interviews. The interviews and the questionnaire lasted around 10 minutes in every location and 45 minutes in total for each person.

### 3.3.3 Data Collection and Analysis

These four locations were chosen due to their varied acoustic characteristics and their frequent use as informal study environments. Data collection combined in-situ sound level measurements (LAeq), structured questionnaires, and semi-structured interviews to capture both the physical and perceptual aspects of the soundscape. LAeq values were measured using a Brüel & Kjær Hand-held Analyzer Type 2230, positioned at a height of 120 cm and placed centrally within each location. For the questionnaires, responses were obtained from each participant across all four study environments, resulting in 20 completed questionnaires per site and a total of 80 overall. The questionnaire design was informed by the ISO/TS 12913-2:2018 standard. Additionally, to complement the findings from Method C, semi-structured interviews were conducted, allowing students to share more detailed accounts of their experiences. Following Method A outlined in ISO/TS 12913-2:2018, the perceived affective quality of the acoustic environment was assessed across four informal study environments by calculating the mean values of eight perceptual attributes: pleasant, vibrant, eventful, calm, uneventful, monotonous, annoying, and chaotic. Each attribute was rated on a 5-point scale. Statistical analyses were conducted using IBM SPSS Statistics. The nonparametric Kruskal–Wallis H test was applied to examine differences between the ADHD and non-ADHD groups, with a significance threshold set at $p < 0.1$. Additionally, Spearman's rank correlation was used to explore associations between participants' soundscape perceptions and specific sound sources, including natural sounds, human voices, and technological noise. These analyses were performed for the combined sample ($n = 20$) as well as separately for the ADHD ($n = 10$) and non-ADHD ($n = 10$) subgroups, allowing for a detailed investigation of how individual sensory differences shape spatial experience. To enhance interpretability, group-based results were visualized using bar plots and radar charts, enabling a clear comparison of overall soundscape evaluations. This integrated analytical approach effectively highlighted both statistical differences and perceptual trends.

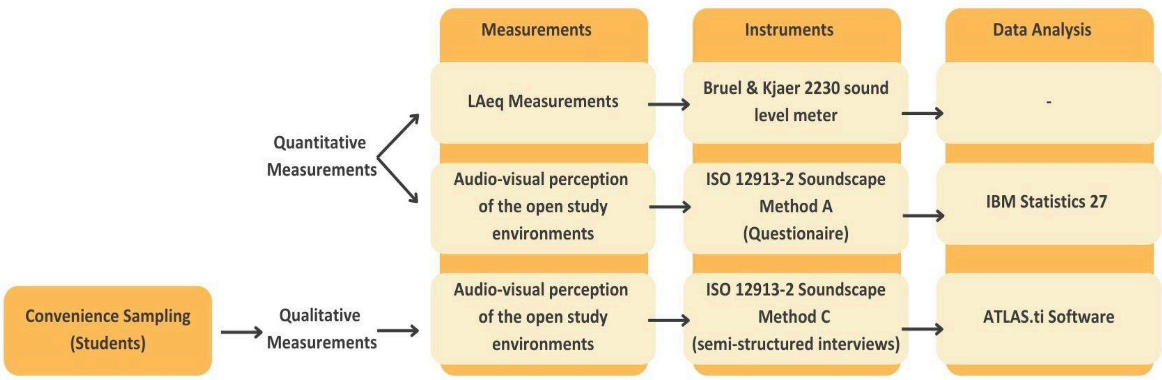


Figure 7: The procedure chart of the study

#### 3.3.3.1 Method C - Grounded Theory

The purpose of the qualitative research is to explore how students who have ADHD perceive visual and acoustic environments in informal study environments. Therefore, the semi-structured interviews were conducted in order to explore the audio-visual perceptions of the students in informal study environments at İ.D. Bilkent University. Data from semi-structured interviews was collected for grounded theory. Furthermore, the questions were designed to be flexible, allowing the interviewer to explore topics in depth based on participants' responses. This approach ensures a rich understanding of the subjective effects of the participants' spatial perception, both acoustically and visually. Each session was audio-recorded with participants' consent to facilitate detailed analysis and approximately lasted 10 minutes. Interviews were stopped when the data reached theoretical saturation, as recommended by the grounded theory approach (Strauss, 2010). The interviews were transcribed and analyzed using thematic analysis. This method involved coding the transcripts to identify key themes and patterns related to the participants' experiences of soundscapes. The transcribed data was converted into a Microsoft Word file and saved to be coded in a program named ATLAS.ti. Therefore, the analysis was conducted using ATLAS.ti 24, following the steps outlined in ISO/TS 12913-2:2018 to maintain consistency with established soundscape research methodologies.

Interviews were structured around several open-ended questions designed to encourage participants to share their personal experiences and the perceived impact of soundscapes on their environment, visual environment, and well-being. Volunteers were expected to answer these questions:

1. What do you hear?
2. What do you want to hear?
3. What do you expect to hear?
4. What do you see?
5. What do you want to see?
6. What do you expect to see?

Figure 8: Semi-structured Interview questions

As demonstrated in figure 8 above, the initial set of three questions focuses on the auditory environment, while the subsequent set of three questions pertains to the visual environment.

In the field of research methodology, the grounded theory involves a series of coding steps. These steps include open coding, axial coding, and selective coding, as outlined by Strauss (2010). During the open coding process, significant concepts were extracted from the raw data. Next, the key ideas were organized into categories for the axial coding process. Finally, during the process of selective coding, subcategories and main categories were established. Then, connections between these categories were established. Once a core category was selected, its relationship with other categories was solidified. Finally, the audio and visual elements of the selected environments were created, resulting in the development of a conceptual framework.

#### 3.3.3.2 Method A - Questionnaire

Method A described in ISO/TS 12913-2:2018 utilizes structured questionnaires that incorporate five-point ordinal category scales to quantitatively evaluate the perception of soundscapes. There  are two main parts of this stage, which are personal demographic information and the questionnaire. While the demographics consist of  age, gender, hearing ability, and usage of medication, the questionnaire part mainly consists of seven parts, which are perceived affective quality, assessments and appropriateness of the environment, auditory and visual environment, and assessment of the entire audio-visual environment. Lastly, the results are presented in scatter plots, enabling a comparative analysis across various environments.

The questionnaires are prepared in Turkish. Before starting, participants were informed about the study's purpose, and consent was obtained before letting them answer the questionnaires. It is also mentioned that all personal identifiers were removed from the transcripts to ensure confidentiality. After that, volunteers were asked to fill out a questionnaire based on Method A for the selected location. Once this was done, the participant and researcher moved to other selected locations, and the process was repeated by first conducting the interview and then asking volunteers to fill out the questionnaire. This approach allowed for the evaluation of volunteers' perceptions of the sound environment and also the visual environment in different informal study environments. The data obtained from the thirty-two participants was analyzed using IBM SPSS Statistics. The research findings will be detailed in the next chapter.

# CHAPTER IV

# RESULTS

## 4.1 Semi-structured Interview (Grounded Theory) Results

To investigate the audio-visual perceptions of students in informal learning environments on İ.D. Bilkent University Campus, semi-structured interviews were conducted, and the main 6 questions were asked to understand their perceptions elaborately. The data obtained from the interview responses were analyzed according to grounded theory method with the help of ATLAS. ti Software. The findings represented in the framework (Figure 9). The interviews were stopped when the answers reached the theoretical saturation.

All interview transcripts were coded using ATLAS.ti, following a systematic, phrase-by-phrase analysis. Each transcript was segmented into concise key phrases representing distinct experiences, perceptions, or responses within the informal learning environments.

To enable comparison, the coding framework was applied separately to three groups: participants with ADHD, participants without ADHD, and themes common to both groups. This allowed differences and overlaps in perceptions to be clearly mapped.Furthermore, hypersensitivity, a recurring theme among ADHD participants, was integrated into the adapted soundscape framework as a novel category, signifying a significant conceptual contribution to the existing literature. The final framework visualizes the relationships between the core category, main categories, and subcategories for each group, illustrating both shared and group-specific patterns of perception.

Analysis of the responses from participants with and without ADHD revealed distinct variations in the impact of the acoustic and visual features of the ILEs on their experiences. Individuals with ADHD indicated a greater tendency to experience negative reactions frequently associated with hypersensitivity, including increased stress, distraction and challenges in sustaining attention in noisy or visually stimulating settings. Instances of positive responses were infrequent and generally showed in less intense and regulated environments. In comparison, participants without ADHD typically reported more favorable or neutral reactions, noting a general sense of comfort and occasional enhancements in concentration, accompanied by only minor distractions in louder environments. In both groups, there were common responses such as temporary lapses in focus triggered by unforeseen auditory stimuli and minor behavioral modifications aimed at mitigating environmental distractions; however, these effects were notably more significant within the ADHD group.Furthermore, while many auditory and visual sensations were commonly identified by both groups, the interpretations of these shared sensations differed noticeably. For instance, laughter was mentioned by both groups as a notable auditory sensation; however, ADHD participants tended to interpret it as a signal of “missing out” on something happening elsewhere, whereas non-ADHD participants more often viewed it as a mood booster that contributed positively to the atmosphere. This instance emphasizes that sensory input alone does not determine the experience; rather, individual perceptual and cognitive characteristics shape how these stimuli are evaluated.

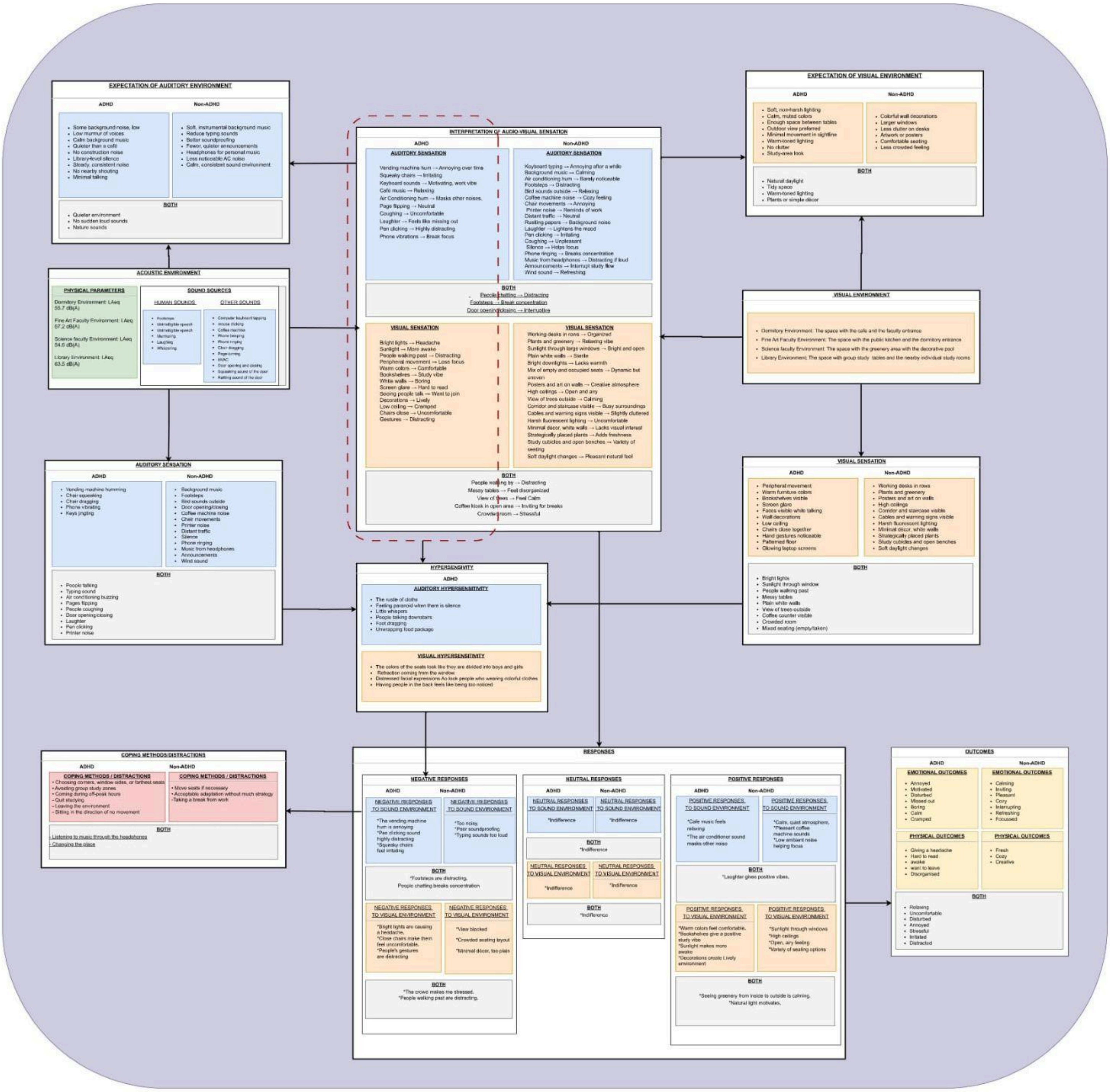

Figure 9: The detailed conceptual framework for both ADHD and non-ADHD participants' audio-visual perception in the informal study environments

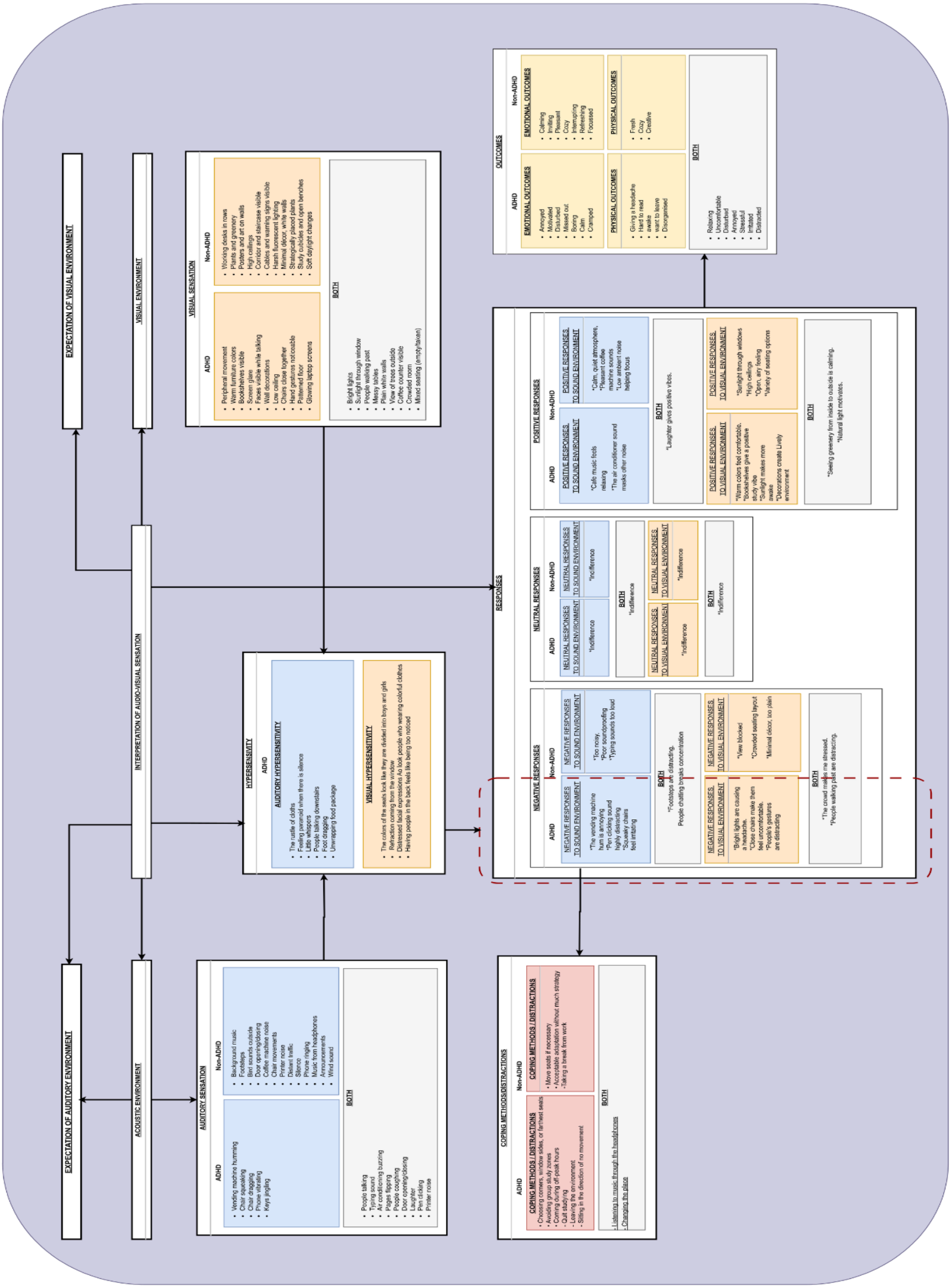


Figure 10: Zoomed-in section A of the framework

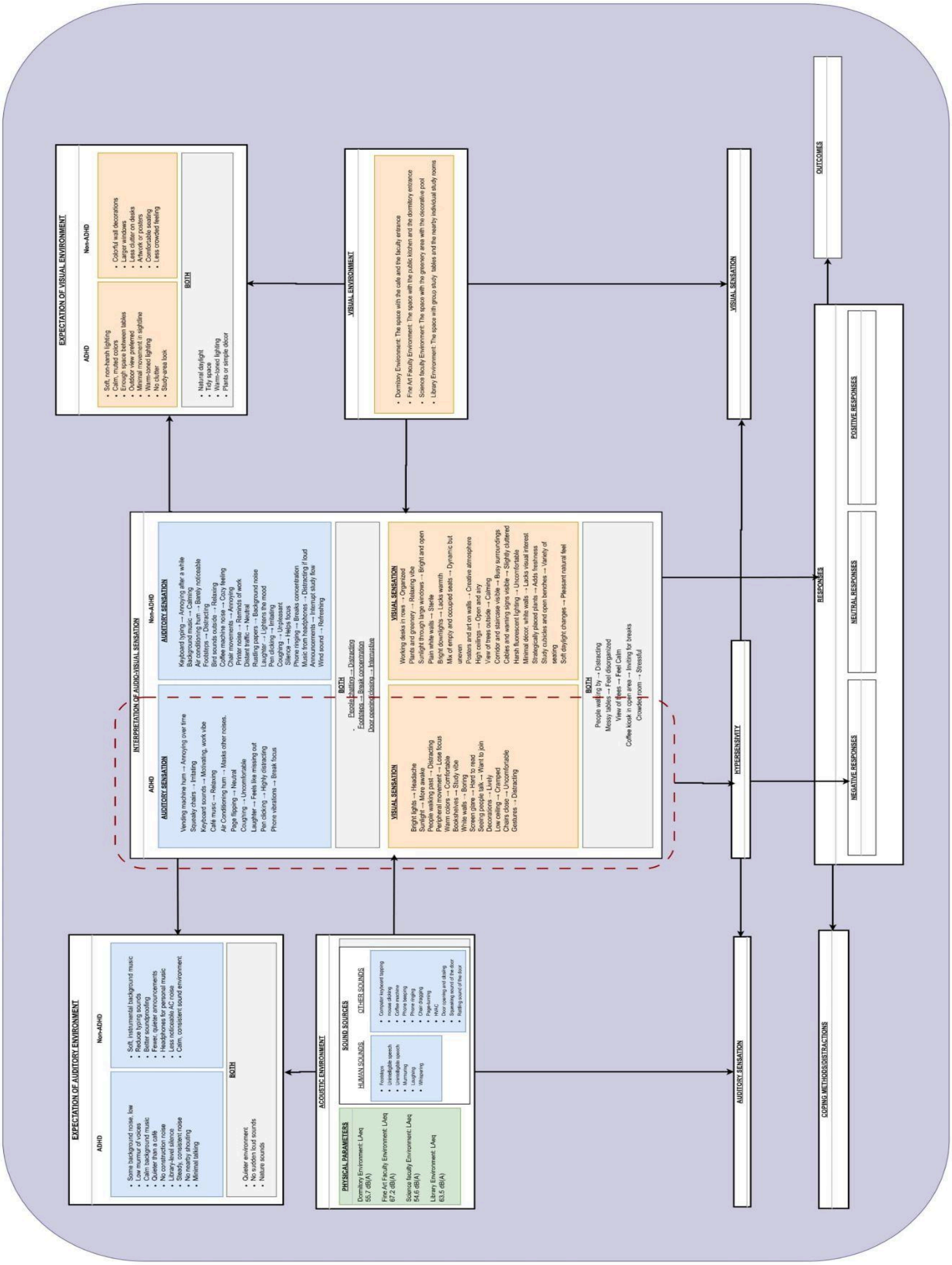


Figure 11: Zoomed-in section B of the framework

***Acoustic Environment & Expectation and Interpretation of Auditory Environment***

The framework analyzes the acoustic environment under two main headings: physical parameters and sound sources. Physical parameters show overall noise exposure  in every four environments, such as dormitory, fine art faculty, science faculty, and library environments, respectively. Sound sources are categorized based on how students with ADHD and those without it perceive the acoustic environment. Intersections are also highlighted in the framework. Therefore, “Expectation of Auditory Environment,” auditory sensation, and auditory hypersensitivity and interpretation of auditory sensation are interconnected with the acoustic environment.

ADHD participants have slightly different perceptions, interpretations, and expectations of the acoustic environment than non-ADHD participants. For instance, ADHD participants have less tolerance for background noise such as HVAC and find it annoying compared to non-ADHD peers. Furthermore, ADHD participants prefer fewer fluctuations in volume and tone. They mostly prefer silence, but white noise and instrumental music, such as soft, classical, and metronomic beats, are also acceptable, while low-volume conversations and controlled background noise is preferred. Sudden and unpredictable noises such as loud door slams and excessive chatter were found highly distractible in both ADHD and non-ADHD participants.

**A:** *I prefer to hear very little, if anything at all. I do not prefer to hear human voices or what they are saying. If they have to talk, I would prefer them to speak in a low voice.*

**B:** *I mean, light music would be nice; it's pleasant. But it would be good if the noise of the air conditioning could be reduced.*

The perception of the acoustic environment is linked to the visual environment, as the overall perception of a setting encompasses more than just auditory elements. For instance, in a campus environment, students often perceive the environments as a single perceptual unit because when they see a group of students chatting around the study table, they also hear their voices as a whole.

***Visual Environment & Expectation and Interpretation of Visual Environment***

The visual environment category examines how students with and without ADHD perceive, interpret, and respond to the visual characteristics of four selected study environments, each with distinct visual attributes. Therefore, there is a link between the visual environment, the expectation of the visual environment, and the perception of the visual environment categories in the framework. Additionally, ADHD students are highly sensitive to the environments they are in, in different ways. Therefore, the category of visual hypersensitivity under the main category in hypersensitivity is also linked  with visual environment and expectation and perception.

ADHD participants have a little different perceptions, preferences, and expectations of the visual environment than non-ADHD participants. Rather than evaluating every visual environment in every place, they perceived mostly the individual elements such as windows, doors, sitting units, posters, lighting elements, safety signs, greenery elements, staircases, and so on. Some students expected more enclosed and private study spaces, with separation elements on study tables. Others preferred a clearer distinction between study areas and social spaces through more structured spatial organization. Because they can get easily overstimulated by a visual environment, such as excessive wall posters, mixed lighting conditions, or high human traffic, they prefer not to sit in front of the windows or  movements, unlike their non-ADHD peers.

**C:** *I might also want to see additional elements such as books, partition panels, or other visual barriers to enhance separation.*

**D:** *Since I usually seek more isolated spaces, the openness of this study area creates issues for me. Being able to see and perceive many things becomes distracting. That's why I would prefer a more private spot, maybe. I wouldn't sit on this side but rather on the other side, facing the wall.*

***Responses & Outcomes***

'Responses' serve as the central category in the framework, with other components circulating around them. The perceptions of both ADHD and non-ADHD participants regarding the auditory and visual environment, along with intervening factors, contribute to the formation of 'Positive Responses,' 'Neutral Responses,' or 'Negative Responses.' Negative responses are also associated with 'hypersensitivity.' All responses to the auditory and visual environments are diverse yet interrelated while being categorized separately for ADHD and non-ADHD participants. However, responses that are shared by both groups are grouped under the 'Both' subcategory within each response category.

**E:** *I think it is good for the study environment to be connected to the outside, not entirely enclosed like a sealed box, but allowing natural light to enter.*

**F:** *I find the paintings very enjoyable. They are definitely acceptable, but they can also be distracting. You might unintentionally focus on them and get lost in thought.*

**G:** *There are lots of plants, and I think it's beautiful. I mean, it looks nice, but it's not overwhelming either.*

**H:** *I can see the upper floors, but, for example, this spot is very nice, very charming. I look at it, I like it, it makes me happy, but I don't get stuck on it.*

***Coping Methods/Distractions***

To reduce negative experiences in the environment, participants develop coping strategies when they must remain in the space. According to their responses, the most common strategies include wearing headphones and, when possible, adjusting their seating position to face away from movement within the environment. If they are able to change the environment, they prefer leaving it and finding a new, proper space for themselves.

**I:** *I don't like hearing scattered sounds at all. But I also don't like hearing highly repetitive sounds. I usually wear headphones.*

***Hypersensitivity***

In addition to the soundscape approach, this study presents hypersensitivity as a separate category since people with ADHD show higher awareness of their surroundings. Compared to their neurotypical peers, this higher perceptual sensitivity can cause variations in how individuals perceive and interpret auditory and visual stimuli. By integrating  hypersensitivity as a key analytical category, the study aims to provide a more distinctive understanding of the interplay between environmental factors and individual sensory processing characteristics. The framework further divides the main hypersensitivity category into auditory hypersensitivity and visual hypersensitivity, presenting them separately. For instance, a little noise difference is enough to distract their attention while studying, such as the rustle of clothes, unwrapping food packages, and people talking downstairs. They often prefer constant noise rather than unexpected sound distractions. Some ADHD participants prefer complete silence while studying. However, when the environment is too quiet, they become highly sensitive to even the slightest noises, which can be even more distracting. Additionally, some participants reported feeling paranoid in extremely silent settings, further affecting their ability to concentrate.

**J:** *The color of the seats bothers me.*

**k:** *The coffee machine is very disturbing. Well, if it were a bit rhythmic, like a continuous beeping sound at certain intervals, there wouldn't be a problem, but because the sound comes out of nowhere at unexpected moments, it's very stimulating.*

### 4.2 Equivalent Continuous A-Weighted Sound Level (LAeq) Results

In accordance with ISO/TS 12913-2 (2018), the Equivalent Continuous A-Weighted Sound Level (LAeq) was measured as an objective descriptor of the acoustic environment. Measurements were carried out during the peak hours of each location, as identified through preliminary observation, and generally coincided with the university's exam period. At each of the four sites, a Brüel & Kjaer Hand-held Analyzer Type 2230 sound level meter was used to record LAeq values. Following the guidelines of ISO/TS 12913-3 (2019), the device was placed at a height of 150 cm in the central point of each space. Three-minute recordings were taken at every location during the designated observation hours. The mean Equivalent Continuous A-Weighted Sound Level (μLAeq) for each location is presented in Table 1.

| **Locations** | **Dormitory** | **Fine Art Faculty** | **Science faculty** | **Library** |
|---|---|---|---|---|
| **LAeq dB(A)** | 55.7 | 67.2 | 54.6 | 63.5 |

Table 1: The average A-weighted sound Level (μLAeq) of the four locations

### 4.3 Method A Perceived Affective Quality (PAQ) Results

#### 4.3.1 Spearman's Rho Correlation Test

The Spearman correlation results indicate clear associations between participants' subjective soundscape perceptions and the types of sound sources present in the environment. When all participants (ADHD and non-ADHD) were analyzed together (Table 2), strong inverse correlations were particularly evident between the perception of “annoying” and multiple sound sources. For example, in the Faculty of Fine Arts, “annoying” was strongly and significantly negatively related to general sound sources (rs = −0.750, p < 0.001). In contrast, positive descriptors such as “comfortable” and “calm” were positively linked to natural sounds, most notably in the Fine Arts and Library contexts. Human-related sounds also showed a noteworthy negative association with the perception of “chaos.”

| Attribute | Dormitory | | Fine Arts Faculty | | Science Faculty | | Library | |
|---|---|---|---|---|---|---|---|---|
| | $r_s$ | p-value | $r_s$ | p-value | $r_s$ | p-value | $r_s$ | p-value |
| Comfortable | 0.309 | 0.185 | **0.578** | **0.008** | **0.475** | **0.034** | **0.519** | **0.019** |
| Annoying | **-0.640** | **0.002** | **-0.750** | **0.000** | -0.382 | 0.097 | **-0.621** | **0.003** |
| Calm | 0.261 | 0.267 | **0.535** | **0.015** | **0.487** | **0.029** | 0.436 | 0.054 |
| Chaotic | -0.342 | 0.140 | **-0.599** | **0.005** | -0.247 | 0.294 | -0.143 | 0.547 |
| Human Sounds | **-0.486** | **0.030** | -0.400 | 0.081 | -0.089 | 0.708 | -0.420 | 0.066 |
| Natural Sounds | -0.378 | 0.100 | **-0.463** | **0.040** | 0.378 | 0.100 | 0.378 | 0.100 |
| App. Sound Env. | **0.644** | **0.002** | 0.214 | 0.365 | 0.395 | 0.085 | 0.184 | 0.438 |
| Ass. Vis. Env | 0.016 | 0.945 | 0.233 | 0.323 | -0.166 | 0.484 | -0.285 | 0.223 |
| App. Vis. Env. | 0.227 | 0.335 | 0.131 | 0.581 | -0.218 | 0.357 | -0.002 | 0.995 |
| Ass. AV. Env. | 0.200 | 0.397 | **0.691** | **0.001** | 0.099 | 0.677 | **0.764** | **0.000** |

Table 2: Spearman’s correlation between subjective sound environment assessment and specific sound sources across different environments (ADHD and non-ADHD combined, n = 20). Bold values denote p < 0.05.

The “AV. Env.” measure, which jointly evaluates the auditory and visual qualities of the environment, was positively correlated with general satisfaction (rs = 0.731, p = 0.016) in the combined sample. This finding underlines the importance of multisensory integration of environmental cues in shaping satisfaction levels. In the non-ADHD subgroup (Table 4), a particularly strong relationship emerged between audiovisual environment evaluation and soundscape satisfaction within the Faculty of Fine Arts (rs = 0.771, p = 0.009). In contrast, most correlations in the ADHD group failed to reach statistical significance, suggesting higher levels of individual variability within this population.

| **Variable** | **Dormitory** | | **Fine Arts Faculty** | | **Science Faculty** | | **Library** | |
|---|---|---|---|---|---|---|---|---|
| | $r_s$ | p-value | $r_s$ | p-value | $r_s$ | p-value | $r_s$ | p-value |
| Noise Tech | -0.203 | 0.574 | 0.337 | 0.340 | 0.051 | 0.889 | 0.071 | 0.845 |
| Human Sounds | -0.584 | 0.076 | -0.101 | 0.782 | -0.096 | 0.792 | -0.555 | 0.096 |
| Natural Sounds | -0.522 | 0.122 | -0.406 | 0.244 | 0.522 | 0.122 | 0.522 | 0.122 |
| App. Sound Env. | 0.579 | 0.079 | 0.019 | 0.958 | 0.332 | 0.349 | -0.101 | 0.781 |
| Ass Vis. Env. | 0.156 | 0.668 | -0.519 | 0.124 | -0.174 | 0.631 | -0.216 | 0.548 |
| App. Vis. Env. | 0.462 | 0.179 | 0.201 | 0.577 | -0.261 | 0.466 | 0.454 | 0.187 |
| Ass. AV. Env. | 0.454 | 0.188 | 0.156 | 0.668 | 0.234 | 0.516 | **0.731** | **0.016** |

Table 3: Non-ADHD Spearman’s correlation between subjective sound environment assessment, specific sound sources, across different environments (Non-ADHD participants only, n = 10). Bold values denote p < 0.05.

| **Variable** | **Dormitory** | | **Fine Arts Faculty** | | **Science Faculty** | | **Library** | |
|---|---|---|---|---|---|---|---|---|
| | $r_s$ | p-value | $r_s$ | p-value | $r_s$ | p-value | $r_s$ | p-value |
| Noise Tech | -0.055 | 0.879 | 0.194 | 0.591 | -0.225 | 0.532 | 0.042 | 0.909 |
| Human Sounds | -0.313 | 0.378 | -0.221 | 0.540 | 0.044 | 0.904 | 0.072 | 0.844 |
| App. Sound Env. | **0.715** | **0.020** | 0.175 | 0.628 | 0.362 | 0.304 | 0.389 | 0.266 |
| Ass. Vis. Env. | 0.014 | 0.970 | 0.097 | 0.789 | -0.311 | 0.381 | -0.369 | 0.294 |
| App. Vis. Env. | -0.025 | 0.945 | -0.546 | 0.102 | -0.187 | 0.604 | -0.523 | 0.121 |
| Ass. AV. Env. | 0.191 | 0.597 | **0.771** | **0.009** | -0.261 | 0.466 | 0.492 | 0.149 |

Table 4: Non-ADHD Spearman’s correlation between subjective sound environment assessment, specific sound sources, across different environments (Non-ADHD participants only, n = 10). Bold values denote p < 0.05.

### 4.3.2 Kruskal–Wallis H test

Analysis with the Kruskal–Wallis H test (Table 5) indicated significant variations in soundscape perception between individuals with and without ADHD in certain environments. Within the Faculty of Fine Arts, a notable difference was found for the "annoying" attribute ($H = 7.19$, $p = 0.007$). In the dormitory setting, ADHD participants rated the qualities of "calm" ($H = 6.24$, $p = 0.012$), "vibrant" ($H = 4.93$, $p = 0.026$), and "annoying" ($H = 4.01$, $p = 0.045$) differently from their non-ADHD peers. Overall, these outcomes reinforce the notion that people with ADHD tend to perceive the sound environment more negatively, particularly in less controlled settings.

| Environment | Attribute | H statistic | p-value |
|---|---|---|---|
| Fine Arts Faculty | Annoying | 7.19 | **0.007** |
| Dormitory | Calm | 6.24 | **0.012** |
| Dormitory | Vibrant | 4.93 | **0.026** |
| Dormitory | Annoying | 4.01 | **0.045** |
| Library | Eventful | 3.20 | 0.074 |
| Dormitory | Uneventful | 2.83 | 0.093 |
| Fine Arts Faculty | Pleasant | 2.74 | 0.098 |
| Fine Arts Faculty | Chaotic | 2.70 | 0.100 |
| Science Faculty | Uneventful | 2.70 | 0.100 |

Table 5: Kruskal–Wallis H test results comparing ADHD and non-ADHD participants' ratings of perceptual attributes across different environments. Only results with $p < 0.1$ are reported.

The two-dimensional circumplex model was applied to assess eight perceptual attributes for two participant groups—students with ADHD and those without—across four informal learning environments. Each axis of the model represents a subjective descriptor (e.g., Annoying, Calm, Eventful), rated on a 1–5 Likert scale. The visualizations illustrate perceptual patterns within each setting: orange areas depict the mean scores of the ADHD group, while blue areas reflect those of the non-ADHD group. Differences in the shapes and spreads of these profiles highlight where the groups' audio-visual perceptions diverge most (Figure 12). Higher scores correspond to stronger agreement with the associated attribute.

The findings from the four spaces—Dormitory, Faculty of Science, Library, and Faculty of Fine Arts—indicate that ADHD participants tend to interpret soundscapes more sensitively and in distinct ways compared to their peers. In the dormitory, elevated ratings for negative descriptors such as "chaotic" and "annoying" by the ADHD group point to the distracting and disruptive qualities of the dense sensory environment. Conversely, in the Faculty of Science, ADHD participants gave lower "chaotic" scores but reported higher "uneventful" and "annoying" ratings. In the library, perceptions between the groups were generally similar; however, ADHD students found the environment less eventful overall, suggesting that excessive quietness may reduce stimulation for some individuals. The Faculty of Fine Arts received the least favorable assessments, with the ADHD group rating it high on "chaotic," "annoying," and "monotonous," possibly due to inconsistencies in its sound environment. Overall, these results suggest that individuals with ADHD are sensitive to both overstimulation and understimulation, and that soundscapes with a balanced and varied sensory profile are more likely to foster positive perceptions


Figure 12: Two-dimensional circumplex model comparing mean perceptual ratings between ADHD and non-ADHD participants across four university environments.

Figure 4 shows the subjective assessments of the environmental sound environment of the participants in the study, in comparison with their diagnosis of attention-deficit/hyperactivity disorder (ADHD). Box plots visualize the distribution, with statistical measures such as median, mean, interquartile range (IQR), and outliers revealing within-group consistency and differences. The library exhibited the most significant differentiation between the ADHD and non-ADHD groups. While participants without ADHD evaluated this space more positively (median = 4.0), individuals with ADHD gave lower scores (median = 2.5), suggesting that the acoustic properties of the space may be more challenging for individuals with ADHD. The dormitory environment, on the other hand, exhibited a more heterogeneous distribution, with more variability and a wide IQR; this suggests that more unstructured or uncontrolled spaces may increase perceptual differences in these individuals. Overall, participants with ADHD tended to rate the sound environment less favorably than their non-ADHD counterparts, as indicated by both lower mean and median scores across most environments. The only exception was the Science Faculty, where ADHD participants gave slightly higher ratings than the non-ADHD group. Notably, the Science Faculty also exhibited the most similarity between groups, with high and overlapping ratings, suggesting that it may offer a more acoustically neutral or structured environment that supports both groups equally well. The library stood out among individuals with ADHD, with a narrower quartile range and generally lower ratings, suggesting that silence may have been experienced as a trigger for distraction in these individuals. Overall, the figure suggests that group-based perceptual differences are closely related not only to sound level but also to environmental structure and contextual arrangements.

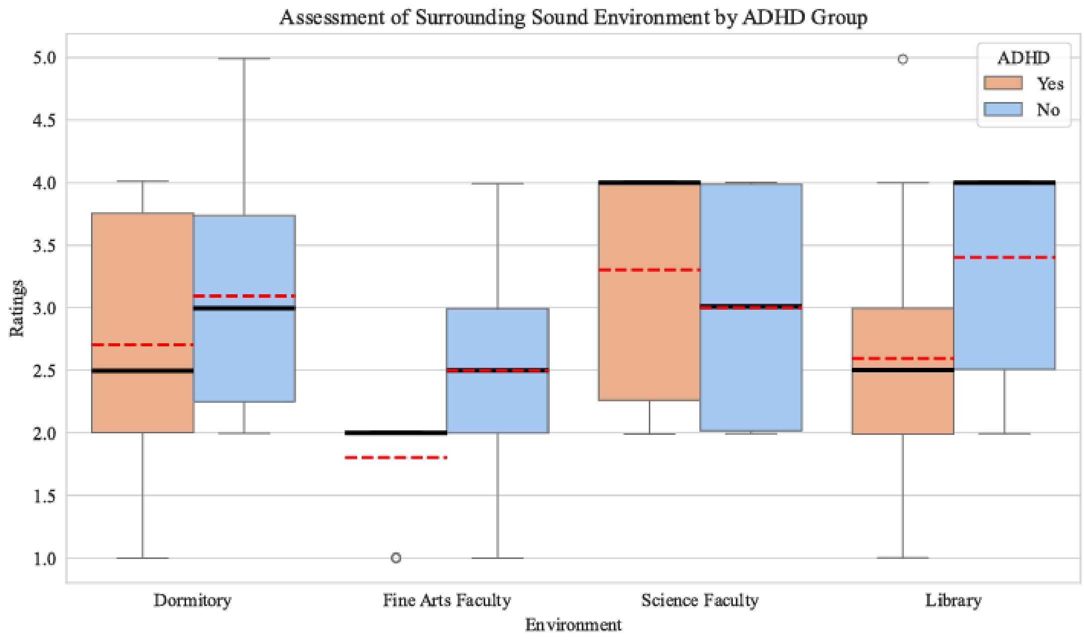


Figure 13: Boxplot comparing participants' ratings of the surrounding sound environment across four campus settings Boxes represent the median; red dashed lines show group means.

### 4.3.3 Assessment and Appropriateness of Sound and Visual Environments

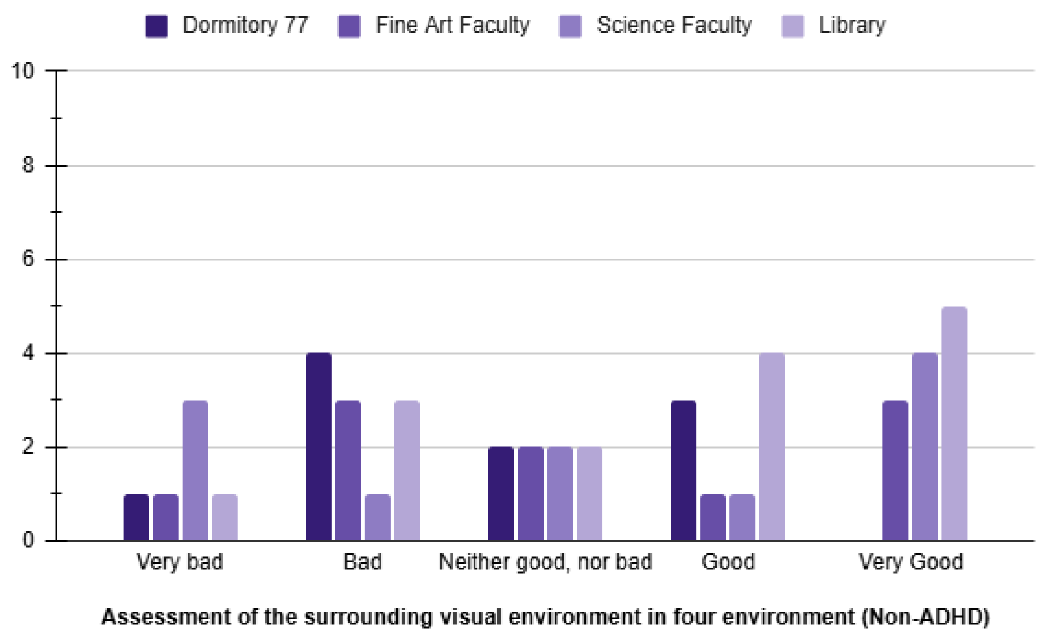


Figure 14: Assessment of the surrounding visual environment in four environment (Non-ADHD)

Assessment of the visual environment for the Non-ADHD group (Figure 14) shows that the Library was most frequently rated as "Good" or "Very Good," while Dormitory 77 received the highest proportion of "Bad" evaluations.

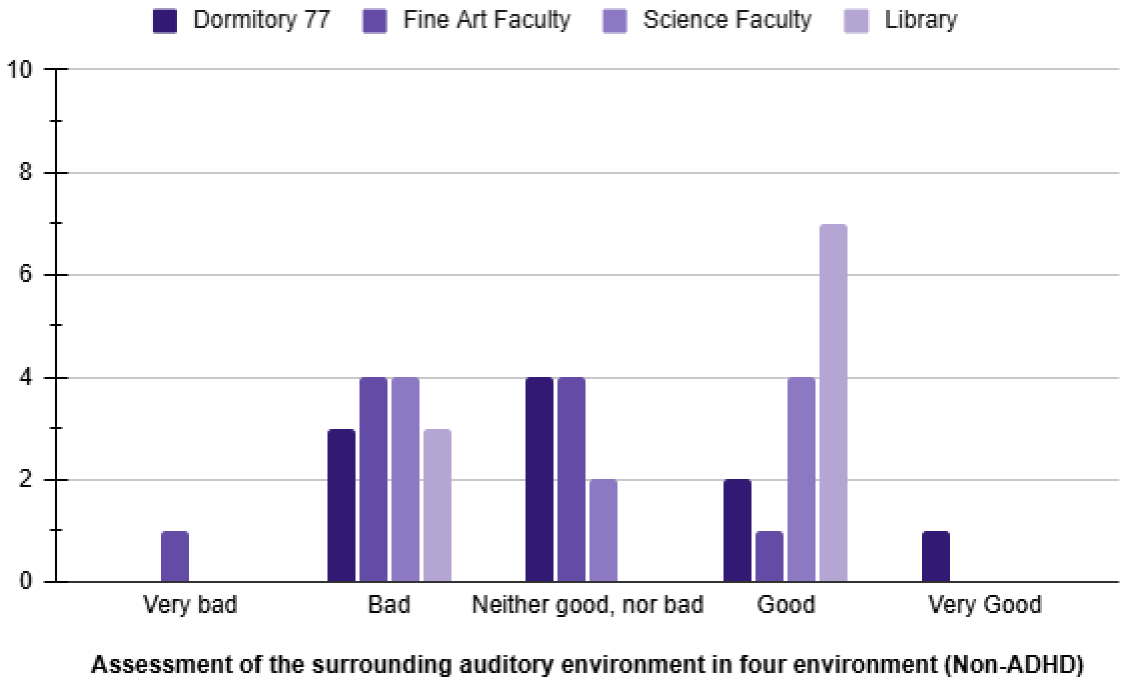


Figure 15: Assessment of the surrounding auditory environment in four environment (Non-ADHD)

In the auditory environment assessment for the Non-ADHD group (Figure 15), the Library achieved the highest "Good" ratings, whereas Fine Art Faculty and Science Faculty had more "Bad" responses.

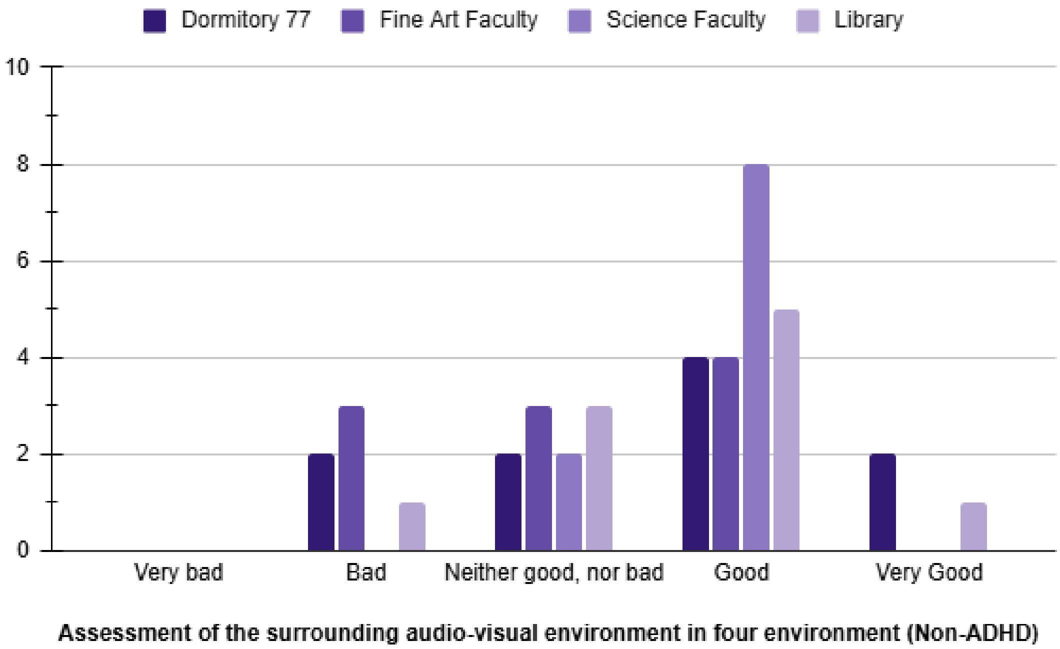


Figure 16: Assessment of the surrounding audio-visual environment in four environment (Non-ADHD)

The Science Faculty most positively evaluated the audio-visual environment for the Non-ADHD group, while Dormitory 77 received more negative ratings (Figure 16).

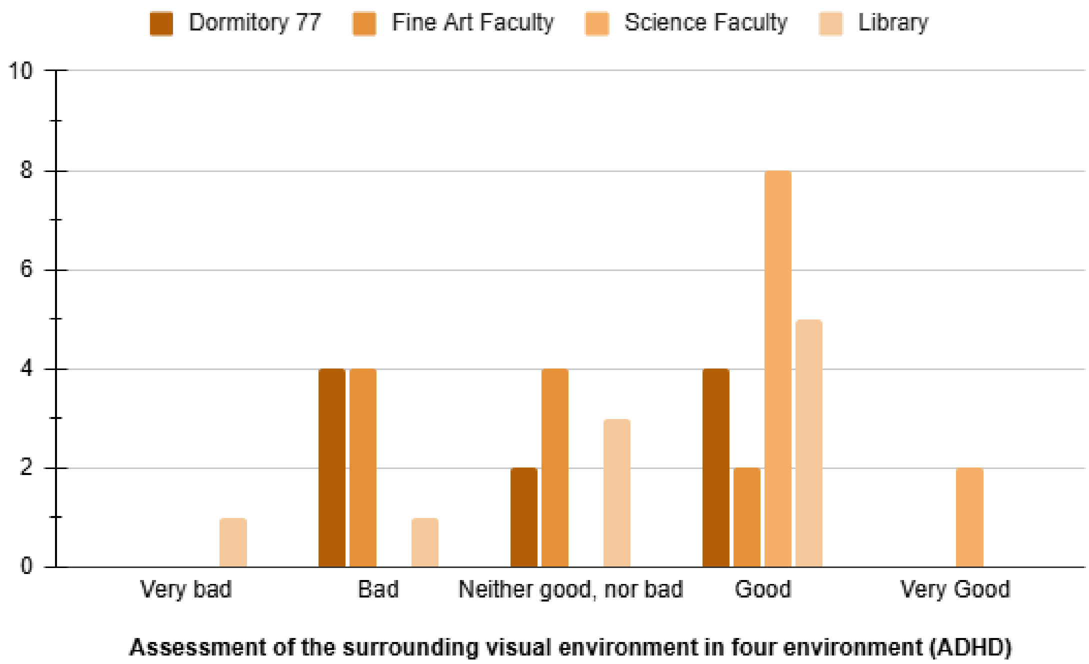


Figure 17: Assessment of the surrounding visual environment in four environment (ADHD)

For the ADHD group's visual environment, Science Faculty obtained the highest "Good" scores, while Dormitory 77 and Fine Art Faculty were more often rated as "Bad." (Figure 17).

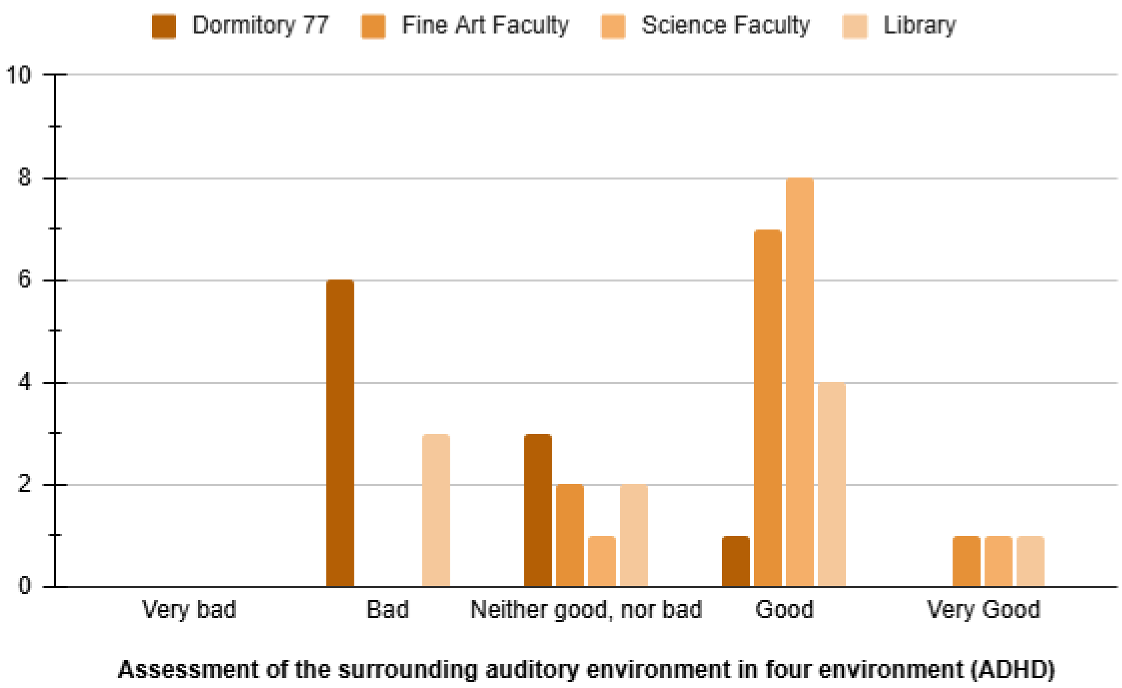


Figure 18: Assessment of the surrounding auditory environment in four environment (ADHD)

In the auditory environment assessment for the ADHD group (Figure 18), Fine Art Faculty and Science Faculty were rated highest in the "Good" category, whereas Dormitory 77 showed the most "Bad" evaluations.

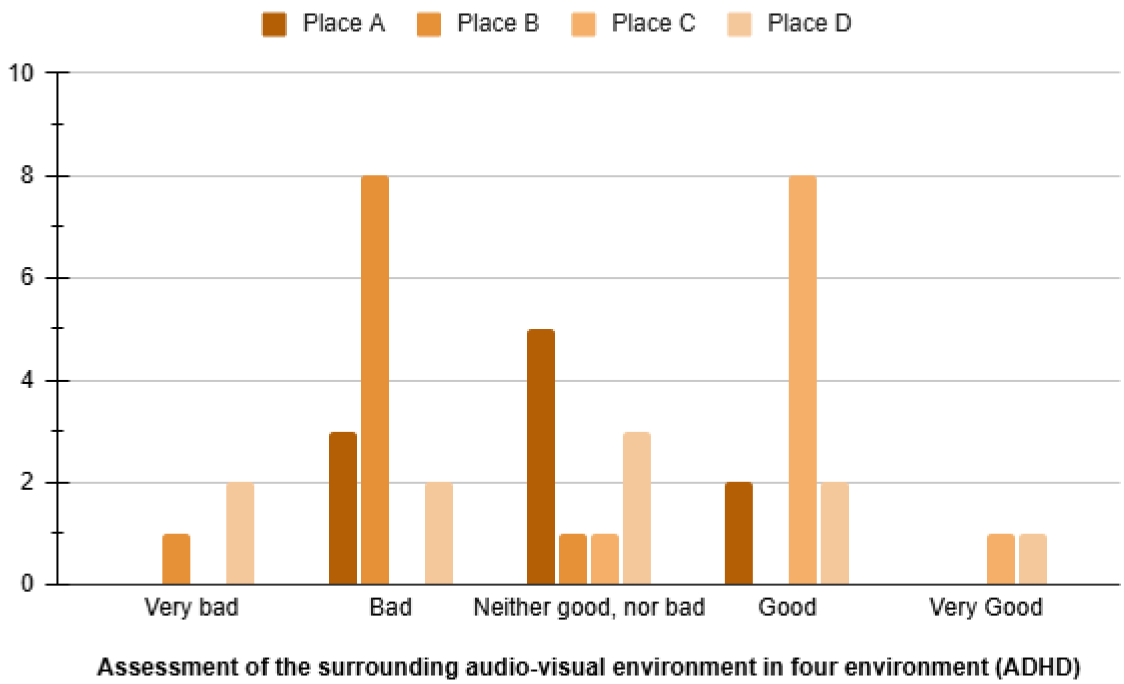


Figure 19: Assessment of the surrounding audio-visual environment in four environment (ADHD)

The ADHD group's audio-visual environment evaluation (Figure 19) revealed that Place B and Place C were frequently rated as "Good," while Place B also had a notable concentration of "Bad" ratings.

# CHAPTER V

# DISCUSSION

## 5.1 Discussion of Grounded Theory (GT) results

The main objective of this study was to construct a comprehensive framework by exploring how students with ADHD perceive informal study environments, particularly in relation to their sensory experiences. Through semi-structured interviews guided by six core questions, it became evident that ADHD participants consistently reported being more overstimulated by their surroundings compared to their non-ADHD peers.

Across the four ILEs, both groups found sudden, unpredictable noises disruptive, but ADHD participants showed markedly less tolerance for continuous mechanical noise (e.g., HVAC) and fluctuating volume levels. They often preferred silence or controlled background sound—white noise or soft instrumental music—while non-ADHD participants were generally more accepting of low-level conversation and stable background noise. Even subtle sounds, such as clothing rustle or distant speech, could draw ADHD participants' attention away from tasks.Non-ADHD participants tended to perceive the space more holistically, while ADHD participants described the environment in terms of discrete, attention-capturing elements—windows, signage, lighting contrasts, and moving people. Many ADHD participants sought more enclosed or visually segmented areas, using partitions or wall-facing seating to minimise distraction. Visual overstimulation also stemmed from symbolic or social cues, such as colour schemes perceived as gendered, indicating that their discomfort could arise from both sensory and cognitive-emotional triggers.For many participants, auditory and visual cues were experienced as a single perceptual unit—seeing a conversation and hearing it as part of one event. For ADHD participants, this coupling often intensified distraction, especially when unpredictable noise coincided with visible movement.While both groups reported strategies such as wearing headphones or repositioning to face away from movement, ADHD participants were more likely to leave the space entirely when overwhelmed. This tendency towards avoidance rather than adaptation suggests that environmental conditions can decisively determine whether they remain in a study space.The framework's inclusion of hypersensitivity as a separate category was strongly supported by the data. Even small sensory changes could alter comfort and concentration levels. Some ADHD participants reported discomfort in overly silent environments, where faint noises became intrusive or unsettling.

The heightened sensory responsiveness reported by ADHD participants is consistent with previous findings on sensory hypersensitivity in neurodivergent populations. Ben-Sasson et al. (2009) describe sensory over-responsivity as reactions that are "faster, longer, or more intense than what is expected" (PMC3149116), a pattern reflected in participants' narratives here. Similar to broader models of sensory processing (Miller & Lane, 2000; Miller et al., 2007), this study underscores the central role of sensory modulation in shaping environmental preferences and comfort. Visual sensitivities observed, such as discomfort from movement, lighting, and visual clutter, align with research highlighting aversion to flicker, patterns, and dynamic scenes in neurodivergent individuals (ScienceDirect S0042698925001014).

Participant reactions to color-coded furniture further suggest that symbolic meaning in environmental design can add to cognitive load.

Crossmodal activation effects documented in earlier work (Molholm et al., 2002; McDonald et al., 2013; Hillyard et al., 2016) provide a possible explanation for why participants became overstimulated in spaces with combined sensory triggers. This aligns with the multisensory coupling described by participants in the present study.Compared with previous research on informal learning spaces, such as Acun and Yilmazer (2018), the present findings highlight the importance of individual cognitive and sensory profiles. While Acun and Yilmazer found no direct link between measured sound levels (LAeq) and satisfaction, ADHD participants here reported discomfort even at moderate levels—suggesting that physiological and cognitive responses are key determinants of perception. Moreover, visual elements, absent in Acun and Yilmazer's analysis, emerged as critical factors in this study.Zhang et al. (2025) similarly noted that students with high sound sensitivity preferred quieter ILEs, but did not address neurodiverse groups or multimodal sensitivities. By including both ADHD and non-ADHD participants and exploring visual as well as auditory dimensions, this study expands on Zhang et al.'s framework. The use of in-depth interviews also revealed behavioural outcomes of hypersensitivity—such as avoidance of certain spaces—that structured questionnaires may miss.

In conclusion, this study contributes a neurodiversity-aware, multisensory perspective to the design of ILEs, emphasizing the need for predictable, low-variance sensory environments, clear zoning, and flexible design to accommodate a broader range of users.

### 5.2 Discussion of Perceived Effective Quality (PAQ) results

This study compared the auditory and visual environmental perceptions of university students with and without ADHD in four different informal learning environments. Overall, the findings revealed that students with ADHD rated these environments as more chaotic, less calming, and generally less enjoyable, while students without ADHD expressed more positive and comfortable evaluations. Participants in the ADHD group demonstrated sensitivity to both high and low levels of environmental stimuli, highlighting the importance of sensory balance in learning environments. It is also revealed that there are negative correlations between "disturbing" and sound sources across all participants, while perceptions of "comfortable" and "calm" were positively correlated, particularly with natural sounds. Furthermore, analyses specific to the ADHD group revealed a significant correlation between audio-visual environment perception and overall satisfaction in the library environment, but correlations were weaker and more variable across the group. Conversely, the non-ADHD group's evaluations were more consistent and less sensitive to environmental stimuli. According to the results, there were statistically significant differences between the groups in attributes such as "disturbing," "calm," and "vibrant," particularly in the Fine Arts Faculty and dormitory environments. The results are also showed that ADHD group, in particular, evaluated the Fine Arts and dormitory environments more negatively, while the Faculty of Science was perceived as the most neutral and balanced for both groups.

The field of soundscape research is evolving beyond traditional noise-based evaluations toward a more perceptual and contextual approach. ISO 12913-1 defines soundscape as *“the acoustic environment as perceived or experienced by individuals* *in context"* (ISO, 2014), emphasizing the subjective and relational nature of auditory experience. Recent research (Fang et al., 2021) confirms that perceptual qualities such as "pleasant" and "annoying" are not solely determined by sound pressure levels, but are also influenced by the type of sound, as well as individual preferences and sensitivities. In the present study, ADHD students reported challenges in both noisy environments (e.g., Fine Arts) and quiet environments (e.g., Library). This finding underscores that, for neurodivergent individuals, soundscape perception is shaped not only by environmental characteristics but also by heightened sensory processing and context-dependent cognitive load.

Furthermore, previous studies have highlighted the nuanced relationship between natural sounds and noise in shaping soundscape perceptions. The addition of positive natural sounds, such as birdsong, has been shown to mask unwanted noise, thereby improving the overall perception of otherwise noisy environments (Hong et al., 2020). The current study aligns with these findings, revealing a significant negative correlation between the perception of "disturbing" and the presence of sound sources across all participants. Conversely, attributes such as "comfortable" and "calm" were positively associated with natural sounds, particularly in acoustically diverse settings like the Fine Arts building and the Library. These results reinforce the idea that natural auditory elements can have a restorative effect, mitigating the negative impacts of ambient noise and enhancing the affective quality of informal learning environments.

### 5.3 Outcomes for Informal Learning Environments

Spatial perception varies across environments; it is essential for designers to consider user preferences and responses to design indoor environments. It is especially important in campus study areas that provide diverse user groups. Although students with ADHD may represent a numerical minority, inclusive design should aim to integrate rather than alienate them. Therefore, this study provides a valuable perspective on addressing user diversity in informal study environments in a campus setting.

To gain complementary perspectives, every study environment chose different spatial characteristics. However, some responses and preferences are common when participants are provided with positive auditory and visual environments. Participants responded positively to some visual elements such as artworks, indoor plants, empty walls, natural light, and high ceilings. Most of them preferred more study tables and seating but fewer people in the study environments

# CHAPTER VI

# CONCLUSION

This study examined how students with and without ADHD perceive and respond to the acoustic and visual qualities of four informal learning environments (ILEs) at İ.D. Bilkent University. Using a combination of on-site sound measurements, questionnaires, and narrative interviews—based on Methods A and C of ISO/TS 12913-2:2018—it offered a detailed picture of how individual traits and environmental factors interact to shape these experiences. The results show that students with ADHD generally display heightened sensitivity to sensory input, interpreting both sound and visual elements as more distruptive than their peers without ADHD. This hypersensitivity, a key theme of the study, not only influenced how comfortable they felt in an environment but also shaped the strategies they used to cope, ranging from subtle self-adjustments to actively avoiding certain environments or just leaving the environment instead of coping. In contrast, non-ADHD participants were more likely to adapt to changing conditions, perceiving the same settings as less disruptive. These findings underline the importance of designing ILEs that cater to a range of sensory needs, particularly for neurodiverse learners. Providing spaces with varied acoustic and visual conditions, flexible layouts, and controllable sensory features could help create more inclusive and equitable study environments. By introducing hypersensitivity into the soundscape framework, this research also expands the scope of ISO-based approaches, offering a new lens for understanding and improving the experiences of students with diverse sensory profiles.

### Limitations

This study faced several limitations that should be considered when interpreting the findings. First, recruiting and engaging participants with ADHD in the in-situ interview process was challenging. Securing voluntary participation required significant effort, and maintaining participants' attention during the interviews proved difficult. On multiple occasions, questions had to be repeated two or three times, as some participants became distracted or drifted into unrelated thoughts, which extended the overall data collection process.Second, the participants were under different types of ADHD medication, including both short-release and long-release formulations. Although they were asked to attend the study sessions without taking their medication on the day of the interview, those on long-release formulations reported that the effects might persist, potentially influencing their responses. This variation in medication type and release mechanism may have introduced uncontrolled variability in the data. Overall, these factors may have influenced the pace, depth, and consistency of the responses and thus should be taken into account when generalizing the results.

### Future Research

Future research could investigate how time of day, such as morning versus evening, and seasonal variations influence students' perceptions of informal learning environments. Longitudinal approaches may provide valuable insights into how these perceptions evolve over time and with continued experience in the same spaces. Additionally, virtual reality (VR) simulations could be employed to test alternative design scenarios in a controlled and immersive setting, offering a practical tool for evaluating potential environmental modifications before implementation.

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# APPENDIX

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**A GROUNDED THEORY APPROACH: EXPLORATION OF STUDENTS' PERCEPTIONS IN INFORMAL STUDY ENVIRONMENTS, WITH A FOCUS ON ATTENTION DEFICIT AND HYPERACTIVITY DISORDER (ADHD)**

**PARTICIPANT DEBRIEFING SHEET**

Thank you for participating in our study.

In this study, we are investigating how visual and auditory perceptions vary among students with and without Attention Deficit Hyperactivity Disorder (ADHD) in four study environments within the Bilkent University campus.

Please let the researchers know right away if, for any reason, you wish that your data is not included in the study.

If you have any further questions about the study or if you wish to find out the results, please don't hesitate to contact any of the researchers at the contact information given above.

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**A GROUNDED THEORY APPROACH: EXPLORATION OF STUDENTS' PERCEPTIONS IN INFORMAL STUDY ENVIRONMENTS, WITH A FOCUS ON ATTENTION DEFICIT AND HYPERACTIVITY DISORDER (ADHD)**

**PARTICIPANT INFORMATION AND CONSENT FORM**

**Who is carrying out the study?**
You are invited to participate in a study conducted by Ceren Şahmaran as part of a research project at Bilkent University.

**What is the study about?**
This study is looking at how visual and auditory perceptions vary among students with and without Attention Deficit Hyperactivity Disorder (ADHD) in four study environments within the Bilkent University campus.

**What does the study involve?**
You will be asked to engage in two main phases:

- The first phase involves semi-structured interviews, where your responses will be audio recorded and transcribed.
- The second phase will involve completing a questionnaire that includes a two-dimensional rating scale assessing your perceptions of the acoustic and visual environments in your study space.

**How much time will the study take?**
It will take approximately 45 minutes.

**Will the study benefit me?**
The study will not benefit you directly in terms of compensation. However, it aims to enhance the understanding of how students perceive their study environments, which could contribute to future improvements in these spaces. You will receive a debriefing with more detailed information about the study after your participation is completed.

Also, You will be compensated for your participation with coffee and dessert after the study. Additionally, you will receive more detailed information about the study once your participation is complete.

Feel free to adjust any part of it if needed!

**Participant Number:**

**Date:**
**Place:**
**Hour:**

# Questionnaire Survey

**Sesli çalışma alanlarında dikkat dağınıklığı ve hiperaktiviteye sahip öğrencilerin ses ve görsel algısı Araştırması**

Bu anket Çalışması, İ.D. Bilkent Üniversitesi İç mimarlık ve Çevre Tasarımı Bölümü'nde hazırlanan dikkat dağınıklığı ve hiperaktiviteye sahip öğrencilerin ses ve görsel algısının incelenmesi kapsamında yapılmaktadır. Ankette kimliğiniz sorulmamaktadır. Tüm katılımcılardan elde edilen veriler kesinlikle gizli tutulup, sadece bilimsel amaçla kullanılacaktır. Katılım isteğe bağlıdır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz **ceren.sahmaran@bilkent.edu.tr** den bana ulaşabilirsiniz.

**A. Kişisel Bilgiler**

**1.Kaç yaşındasınız?**

..........................................................................................................................

**2.Cinsiyetiniz nedir?**

◯ **Kadın**
◯ **Erkek**
◯ **Diğer**
◯ **Belirtmek istemiyorum**

**1.Eğitim durumunuz nedir?**

◯ **Lisans**
◯ **Yüksek lisans**
◯ **Doktora**

**3. Dikkat eksikliği ve hiperaktivite bozukluğu tanınız var mı? Eğer var ise ne zamandır mevcut?**

..........................................................................................................................

Eğer dikkat eksikliği ve hiperaktivite bozukluğu tanınız yok ise 4. 5. ve 6. soruları cevaplandırmayınız.

**4.Eğer ilaç kullanıyor iseniz hangi ilaçı kullanıyorsunuz?**

..........................................................................................................................

**5.İlacınızı hangi sıklıkla ve kaç mg kullanıyorsunuz?**

..........................................................................................................................

**6.İlacınızı en son ne zaman kullandınız?**

..........................................................................................................................

**B. Anket Bölümü**

**B1. Ses Kaynağı Tanılama**

| **Şu anda dinlediğiniz dört çeşit sesi hangi ölçüde değerlendirirsiniz?**<br>Lütfen her ses çeşidi için bir yanıt seçiniz. | [1]<br>**Hiç** | [2]<br>**Biraz** | [3]<br>**Kısmen** | [4]<br>**Çok Fazla** | [5]<br>**Tamamen Hakim** |
|---|---|---|---|---|---|
| **Teknolojik cihaz sesleri**<br>(Bilgisayar, klima, havalandırma, vb.) | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Diğer sesler**<br>(Siren, inşaat, endüstriyel, vb.) | ☐ | ☐ | ☐ | ☐ | ☐ |
| **İnsan Sesleri**<br>(Diyalog,kahkaha,ayak sesi, vb.) | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Doğa Sesleri**<br>(Kuş sesleri,rügar,yağmur, vb.) | ☐ | ☐ | ☐ | ☐ | ☐ |

**B2. Algılanan Etkin Nitelik**

| **Aşağıdaki her 8 ölçek için, dinlediğiniz ortam sesinin tamamlanmasına ne ölçüde katılır ya da katılmazsınız?**<br>Lütfen her tanım için bir yanıt seçiniz. | [5]<br>**Kesinlikle katılıyorum** | [4]<br>**katılıyorum** | [3]<br>**Ne katılıyorum ne katılmıyorum** | [2]<br>**katılmıyorum** | [1]<br>**Kesinlikle katılmıyorum** |
|---|---|---|---|---|---|
| **-Dinamik** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Tekdüze** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Eğlenceli** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Sıkıcı** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Rahatlatıcı** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Rahatsız Edici** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Sakin** | ☐ | ☐ | ☐ | ☐ | ☐ |
| **-Kargaşalı** | ☐ | ☐ | ☐ | ☐ | ☐ |

**B3. Çevredeki Ses Ortamının Değerlendirilmesi**

| Dinlediğiniz çevredeki ses ortamını genel olarak nasıl tanımlarsınız? | | | | |
|---|---|---|---|---|
| [1] **Çok İyi** | [2] **İyi** | [3] **Ne iyi, Ne Kötü** | [4] **Kötü** | [5] **Hiç Değil** |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**B4. Çevredeki Ses Ortamının Uygunluğu**

| Genelinde, dinlediğiniz var olan ses ortamı mekana ne ölçüde uygundur? | | | | |
|---|---|---|---|---|
| [1] **Hiç değil** | [2] **Çok az** | [3] **Kısmen** | [4] **Çok fazla** | [5] **Mükemmel olarak** |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**B5. Çevredeki Görsel Ortamın Değerlendirilmesi**

| Gördüğünüz çevredeki görsel ortamını genel olarak nasıl tanımlarsınız? | | | | |
|---|---|---|---|---|
| [1] **Çok İyi** | [2] **İyi** | [3] **Ne iyi, Ne Kötü** | [4] **Kötü** | [5] **Hiç Değil** |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**B6. Çevredeki Görsel Ortamın Uygunluğu**

| Genelinde, gördüğünüz var olan görsel ortam bulunduğunuz mekana ne ölçüde uygun? | | | | |
|---|---|---|---|---|
| [1] **Hiç değil** | [2] **Çok az** | [3] **Kısmen** | [4] **Çok fazla** | [5] **Mükemmel olarak** |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**B7. Görsel-İşitsel Ses Ortamın Değerlendirilmesi**

| Bulunduğunuz ortamı genel olarak nasıl tanımlarsınız? | | | | |
|---|---|---|---|---|
| [1] **Çok İyi** | [2] **İyi** | [3] **Ne iyi, Ne Kötü** | [4] **Kötü** | [5] **Hiç Değil** |
| ☐ | ☐ | ☐ | ☐ | ☐ |

**Katılımınız için teşekkür ederim.**